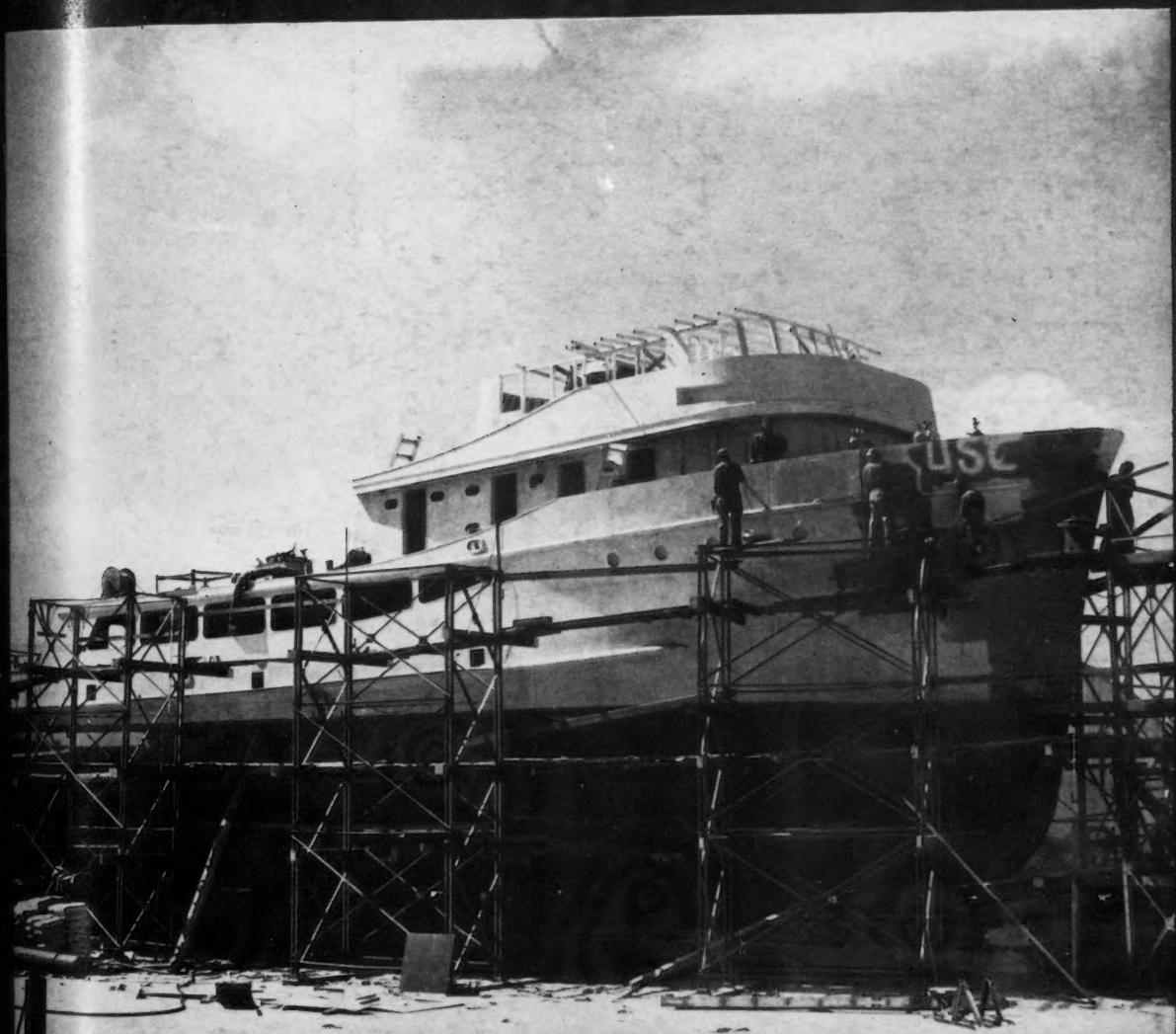


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Official Publication

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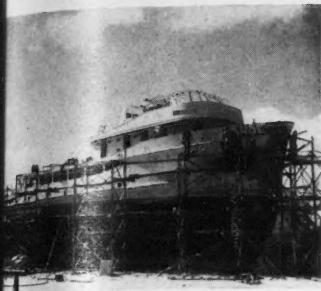
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devoted entirely to

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MAY, 1950

No. 5



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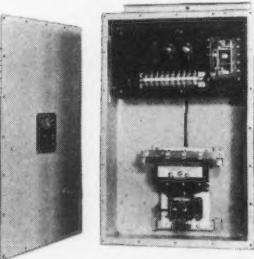


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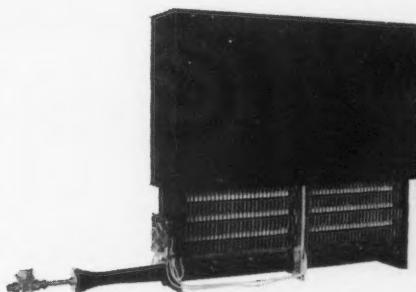
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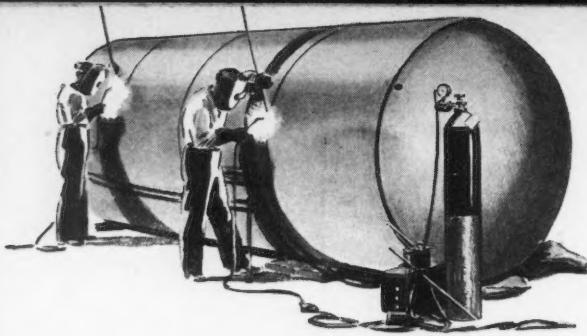
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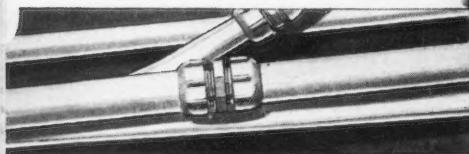
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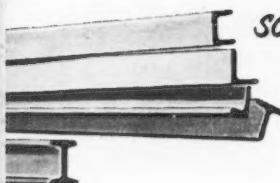
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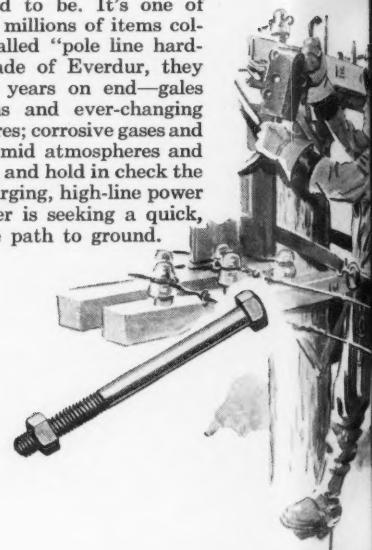
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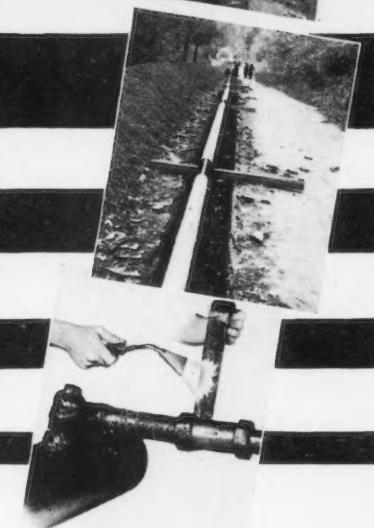
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Corrosion of Metals by Insecticidal Solutions*

By GEORGE S. COOK* and NANCY DICKINSON*

Abstract

The purpose of this investigation was to determine the comparative corrosion resistance of stainless steel, copper, brass, aluminum, magnesium alloy, aluminum alloy, cold rolled steel, and galvanized iron when immersed in various insecticide solutions. The eight metals were immersed in fourteen test solutions for eight weeks and periodic observations were made to determine the extent of corrosion. Weight loss and pitting, as a result of the eight-week immersion, were also determined.

It is concluded that:

- a. DDT in water displays a definite tendency to inhibit corrosion;
- b. 2-4-D inhibited corrosion on all metals tested;
- c. Chlorodane is a corrosive acid insecticide;
- d. Insecticides in kerosene or a fuel oil base are not corrosive;
- e. The most corrosive insecticide solutions are chlorodane in water, sodium arsenite in water, and DDT in salt water;
- f. Stainless steel is the only completely corrosion-resistant metal;
- g. Aluminum is of satisfactory corrosion resistance in all of the solutions except sodium arsenite.

It is recommended that aluminum, aluminum alloys, and Alclad, both with and without a corrosion inhibiting pretreatment such as anodizing, be investigated for their corrosion resistance to chlorodane in water, sodium arsenite in water, and DDT in salt water.

Introduction

THE PURPOSE of this investigation was to determine the comparative corrosion resistance of several metals when immersed in various insecticidal solutions. Insecticidal solutions, applied by spraying, are used for insect control, which is necessary for the health and welfare of military troops in the field. Unfortunately, the corrosive nature of certain of these insecticides reduces the service life of the spraying equipment below reasonable limits. As a result, containers fabricated of stainless steel have been considered as the possible answer. However, this metal is too critical and costly to use in equipment with an intended service life of approximately three years.

The work reported herein was a preliminary evaluation program intended only to eliminate from further study those readily corroded metals and those solutions which showed little or no corrosive action. Further work will be necessary to select the metal most resistant to all insecticide solutions.

Investigation

The corrosion resistance of eight metals (FS-1a magnesium alloy, 24-ST aluminum alloy, aluminum,

yellow brass, copper, cold rolled steel, galvanized steel, and 18-8 stainless steel) was to be determined when exposed to the following solutions:

- A—Distilled water
- B—5% DDT in distilled water
- C—5% sodium chloride in distilled water
- D—5% DDT in 5% salt water
- E—Kerosene
- F—10% DDT in kerosene
- G—Fuel Oil No. 2
- H—5% DDT in Fuel Oil
- I—DDT water emulsion (five parts of a solution containing 25% DDT, 65% xylene, and 10% Triton X-100 to 95 parts of distilled water)
- J—20% DDT, 40% Veliscol, 40% fuel oil
- K—5% chlorodane in kerosene
- L—Chlorodane water emulsion (five parts of a solution containing 25% chlorodane, 65% xylene, and 10% Triton X-100 to 95 parts of distilled water)
- M—1 ounce of 2-4-D (2-4 dichlorophenoxyacetic acid) per gallon of distilled water
- N—8 ounces of sodium arsenite per gallon of distilled water

Procedure

Duplicate panels, one by six inches, of each metal were prepared for each solution by hand sanding and solvent cleaning. The edges of the panels were rounded to reduce "edge attack." After being weighed on an analytical balance, each panel was immersed to a depth of $\frac{2}{3}$ of its length in the test solution contained in a covered pint jar. To allow escape of gases formed during the exposure, the screw cap was not tightly closed. The jars were placed in a constant temperature room (77° F) and the initial pH of each solution was determined. Visual examination and pH measurements were made weekly.

At the end of eight weeks the panels were removed, cleaned of corrosion products by chemical treatment (see Appendix A) and weighed. The milligram loss per square decimeter per day (MDD) was determined. Each panel was examined for pitting and the depths of the ten deepest pits were measured and averaged. Inches penetration per year (IPY) were calculated.

Results

Visual Examination. Visual examination of the test strips showed:

- a. All of the metals were unaffected in all kerosene and fuel oil test solutions.
- b. Stainless steel was unaffected in all solutions

* A paper presented at the Sixth Annual Conference, National Association of Corrosion Engineers, St. Louis, Mo., April 4-7, 1950.

* Engineer Research and Development Laboratories, The Engineer Center and Fort Belvoir, Fort Belvoir, Va.

Table II—Corrosion Results with DDT in Salt Water—shows:

- 1) In the case of aluminum, aluminum alloy, cold rolled steel, magnesium alloy, and galvanized iron, the addition of DDT materially decreased rate of corrosion by the salt water;
- 2) Copper, steel, magnesium and galvanized iron have an excessive corrosion rate.

Table III—Corrosion Results with Other Insecticides in Water—shows:

- 1) 2-4-D reduced the rate of corrosion in all cases and, in addition, was the least corrosive of any solution having a water base;
- 2) Sodium arsenite and chlorodane were the most corrosive solutions on all of the metals and the rate of corrosion was always increased by these solutions over that of distilled water;
- 3) Copper, brass, steel, and galvanized iron have an excessive rate of corrosion.

Table IV—Corrosion Results in Kerosene and Fuel Oil—shows:

- 1) The corrosion rate in the kerosene and fuel oil solutions is considerably less than that in distilled water, and, in general, is so slight as to be negligible;
- 2) There was no pitting of any metal in the kerosene or fuel oil solutions;
- 3) All of the metals tested had satisfactory corrosion resistance properties.

Pitting. The pitting measurements are given in Table V and may be summarized as follows:

- a. Aluminum showed pitting failure in sodium arsenite solution;
- b. Copper showed pitting failure in sodium chloride solution;
- c. Although DDT reduced the rate of corrosion on aluminum alloy and magnesium alloy, it did not reduce pitting failure; in fact, the DDT at times accelerated pitting failure;
- d. The various insecticides increased pitting failure on cold rolled steel;
- e. Although no measurable pits were evident in the case of brass, the brass had chemically "pitted" by a process of dezincification. In this process, the zinc present in the brass is consumed by corrosion, leaving the brittle, strengthless copper, or else the copper is redeposited. This attack destroys the strength and use of copper as completely as if there were an actual physical pit.

Discussion

Weight Loss. The weight loss measurements reported determine the amount of corrosion of the different metals in the various solutions. The corrosiveness of the different solutions can be determined by comparing the MDD for each metal in the different solutions. The MDD does not serve as an accurate measure for comparison of the metals with each other because of the different specific gravity for each metal.

Pitting. The weight loss measurements determine the amount of metal consumed by the corrosion, without specifying the type. A metal that corrodes over its entire surface will not fail as rapidly as a metal that pits severely, even though the weight loss measurement would probably be less on the latter metal (provided due consideration is given to specific gravity).

General. Aluminum was the only metal, except stainless steel, which did not corrode in most of the solutions. The pitting failure that was evident in the sodium

arsenite solution was probably caused by local attack at mechanical breaks in the protective oxide film with which the aluminum coats itself, since aluminum is soluble in sodium hydroxide. (Sodium hydroxide is formed by hydrolysis of the sodium arsenite solution.) It is not known whether the sodium arsenite will attack through a complete protective film. If aluminum were tested in sodium arsenite, after a complete protective film had been applied by such a process as anodizing, the progress of corrosion would probably answer this point. The aluminum alloy showed poor corrosion resistance in many of the solutions. Since the aluminum itself was resistant to most of the solutions, the corrosion of this aluminum alloy is probably due to its alloying metals. The other aluminum alloys, commercially available, would probably be worth investigating in order to find one which would be more resistant. In addition, the aluminum alloy with a surface coating of aluminum for corrosion resistance—such as Alclad—would probably serve as a satisfactory structural and corrosion-resistant material.

Conclusions

It is concluded that:

- a. DDT in water displays a definite tendency to inhibit corrosion;
- b. 2-4-D inhibited corrosion on all metals tested;
- c. Chlorodane is a corrosive acid insecticide;
- d. Insecticides in kerosene or a fuel oil base are not corrosive;
- e. The most corrosive insecticide solutions are chlorodane in water, sodium arsenite in water, and DDT in salt water;
- f. Stainless steel is the only completely corrosion-resistant metal;
- g. Aluminum is of satisfactory corrosion resistance in all of the solutions except sodium arsenite.

Recommendations

It is recommended that aluminum, aluminum alloys, and Alclad, both with and without a corrosion inhibiting pretreatment such as anodizing, be investigated for their corrosion resistance to chlorodane in water, sodium arsenite in water, and DDT in salt water.

APPENDIX A Chemical Cleaning of Panels

METAL	SOLUTION	Tamp.	Length Immersion	Blank Loss
Magnesium Alloy	20% Chromic Acid 1% Silver Nitrate	25° C.	5 Min.	0.0085 g
Aluminum Alloy	5% Phosphoric Acid 2% Chromic Acid Conc. Nitric Acid	25° C. 25° C.	10 Min. 2 Min.	0.0044
Aluminum	5% Nitric Acid 2.5% Oxalic Acid	25° C.	5 Min.	0.0001
Copper	5% Nitric Acid 2.5% Oxalic Acid	25° C.	5 Min.	0.0014
Brass	*	75° C.	3 Min.	0.0022
Cold Rolled Steel	10% Ammonium Citrate made alkaline with Ammonium Hydroxide	80° C.	2 Hrs.	0.0587
Galvanized Nails	Concentrated Ammonium Hydroxide	25° C.	2 Min.	0.0021

* Cleaned by electrolytic method, using—Solution: 5% H_2SO_4 ; Anodes: Lead; Cathode: Test Panel; Cathode Current Density: 1.3 Amp-sq. in.; Inhibitor: Betanaphthol.

Potentials Set Up by Thermal Gradients In Iron Immersed in NaCl Solutions*

By HERBERT H. UHLIG* and OSCAR F. NOSS, JR.**

Abstract

The relative damage caused by galvanically coupling a piece of iron at high temperature to another piece at low temperature in an electrolyte is a question of practical importance. Combinations of this kind occur in designs of industrial equipment such as condenser tubes, water-cooled radiators, boiler tubes, stills, pasteurizing equipment, etc.

A laboratory study of cells in which seamless-steel tubing electrodes were immersed in sodium chloride solutions, with one electrode at 100° C and the other at 25° C, revealed that: 1. The potential difference in 3% NaCl under specific conditions of aeration and stirring is 0.024 volt, with the hot electrode the anode. 2. Decrease of aeration, stirring, or NaCl concentration decreases the measured potential difference. 3. The short-circuit current in 3% NaCl amounted to 0.00043 ampere per square inch, equivalent to an anodic corrosion rate of 0.03 ipy. In nitrogen saturated solution, this current falls to zero. 4. The short-circuit current is limited apparently by polarization of the cathode rather than resistance of the electrolyte between 0.125% and 3% NaCl. It appears that the iron electrode at 100° C as sacrificial anode will cathodically protect iron at 25° C of equal area to which it is coupled in 3% NaCl solution.

THE QUESTION often comes up regarding the galvanic effect of coupling a piece of iron at high temperature with another piece at low temperature, both immersed in an electrolyte. Combinations of this kind occur in many designs of industrial equipment such as condenser tubes, water-cooled radiators, boiler tubes, stills, pasteurizing equipment, etc. How important thermal gradients might be in contributing to corrosion of industrial equipment has been reported in only a few instances.^{1, 2, 3}

The work reported herein is not a complete analysis of differential temperature effects concerning iron immersed in aerated NaCl solutions, but rather a contribution to the point of view that the potentials and consequent corrosion are not necessarily small, and appear to deserve further consideration.

Experimental Setup

Potentials were measured in sodium chloride solutions and, in a few instances, in ferrous sulfate. To minimize gradual change in concentration or temperature of the electrolyte, the cell was set up in a ten-gallon earthenware crock. The solution was kept at a constant temperature of 25° C by means of several

feet of Tygon tubing through which cold water circulated, thereby withdrawing heat supplied continuously by the hot electrode. A motor stirrer, and a glass tube through which air entered the electrolyte for aeration completed the auxiliary equipment. The electrodes consisted of two U-shaped No. 24 gauge seamless steel tubes $\frac{1}{4}$ inch O.D. immersed about 6 inches. Steam could be passed through either electrode by means of suitable connections (Figure 1). This permitted balancing out any slight differences in potential of one electrode compared with the other owing to factors other than temperature difference. The efflux steam temperature was followed by means of a ther-

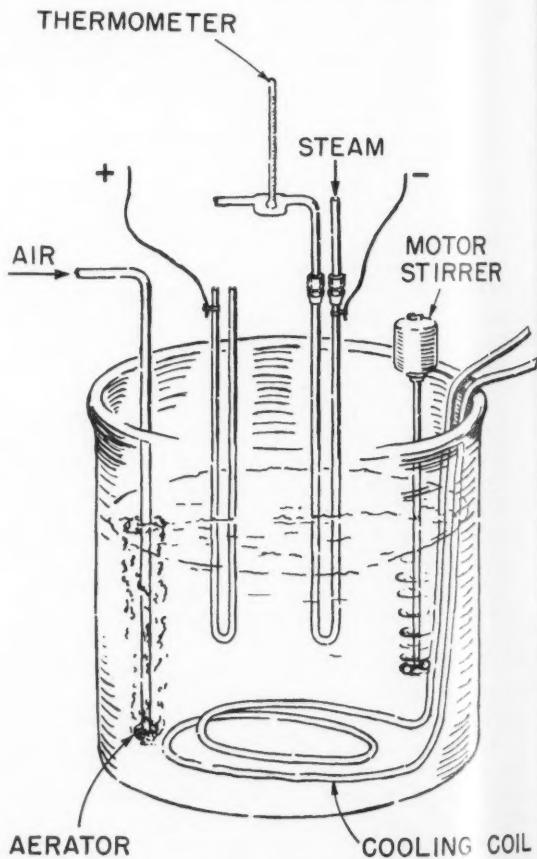


Figure 1—Experimental set-up for measurement of differential temperature potential and current.

* A paper presented at the Sixth Annual Conference, National Association of Corrosion Engineers, St. Louis, Mo., April 4-7, 1950.

** Corrosion Laboratory, Massachusetts Institute of Technology, Cambridge, Mass.

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mmometer inserted in a suitable metal well, and the steam supply adjusted so that the temperature remained at 100° C.

The electrodes were first pickled by inhibited acids, washed, then immersed in the electrolyte, and both short-circuited until their potentials approached each other to within at least a centivolt.

To avoid thermoelectric effects at the wire connections, a 6-inch piece of tubing of the same stock as the electrodes was split longitudinally, and two of these split sections were spot welded to the electrodes. These split sections, in turn, were spot welded to several inches of iron wire the ends of which were soldered to copper wire. This precaution was necessary to avoid potentials at dissimilar metal junctions similar to those set up in thermocouples, with which we were not concerned in this investigation.

The electrodes were mounted on wooden crossarms impregnated with synthetic resin in a manner allowing variable submersion of the electrodes and any desired distance of separation.

Potentials were measured using a student-type potentiometer. The short-circuit current was measured using a "zero resistance" ammeter⁴ which avoided any potential drop through the meter, and allowed, therefore, a more precise evaluation of the differential temperature currents.

Measurements in Sodium Chloride Solutions

The first series of potential measurements was in aerated 3% NaCl. With steam through one electrode and the other electrode at 25° C, the potential difference reached a steady state value in relatively short time and was reproducible to within about ± 4 millivolts. The steam connections were then interchanged and the potential measurement repeated.

In all cases, the hot electrode at 100° C was anode to the cold electrode at 25° C. The potential difference remained steady at 0.024 ± 0.004 volt under the specific conditions of aeration and stirring already described. As explained later, variation of these conditions produced somewhat different values of the potential.

Data are recorded in Figure 2 for runs on two successive days over times extending to 78 hours. There is no reason to expect that the average potential difference would deviate from the above value over longer periods of time.

Effects of Concentration and Stirring

More dilute solutions of sodium chloride showed a decreasing potential difference between hot and cold electrodes, but with the hot electrode remaining the anode (Figure 3). The value became 0.015 volt for aerated 0.125% NaCl compared with 0.024 volt for 3% NaCl.

The effect of stirring was observed by comparing potentials with the motor stirrer in operation and similar potentials with the motor stirrer shut off. The potentials decreased on absence of stirring as shown in Table I. The decrease was about the same for the various concentrations of sodium chloride except for the solution of highest dilution (0.125% NaCl). At the

latter concentration, the polarity of the cell reversed sign, the hot electrode becoming the cathode.

Because both electrodes initially were allowed to remain in the aerated solutions in order to establish steady state potentials, both the electrode surfaces were covered with corrosion products by the time potentials were recorded. The hot electrode in general was covered with a black gelatinous film whereas the cold electrode tended to be covered with a red-brown oxide.

Measurement of Short-Circuit Current

Using a "zero resistance" ammeter, the total current on short circuiting the cell in aerated stirred 3% sodium chloride was 4 milliamperes. Values for more dilute sodium chloride concentrations were somewhat less, and are recorded in Figure 4. Since 12 inches of the $\frac{1}{4}$ -inch diameter electrode were immersed, the corresponding current density in 3% NaCl is 0.00043 ampere per square inch and the equivalent corrosion rate of the anode caused by this current is 0.03 ipy. This represents the initial corrosion rate caused by galvanic coupling of hot iron to cold iron, as in the cell described above, and is about three or more times the normal expected corrosion rate in aerated solutions of this kind. It is likely that the measured current diminishes over a period of days to a constant

TABLE I

Concentration of NaCl:	E.M.F., VOLT		
	With Stirring	Without Stirring	Difference
3.00 percent.....	+.024	+.015	.009
1.50 percent.....	+.022	+.012	.010
0.53 percent.....	+.019	+.010	.009
0.125 percent.....	+.015	-.002	.017

* For positive E.M.F., hot electrode = anode.

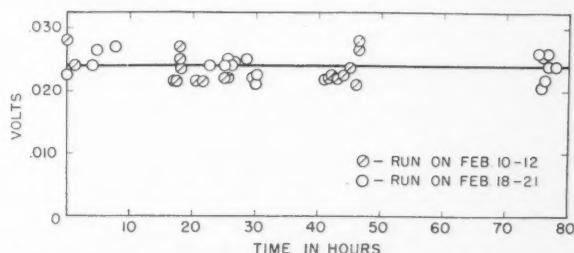


Figure 2—Potential difference between 100-degree C steel electrode and 25-degree C steel electrode immersed in aerated 3% NaCl. (Hot electrode is anode.)

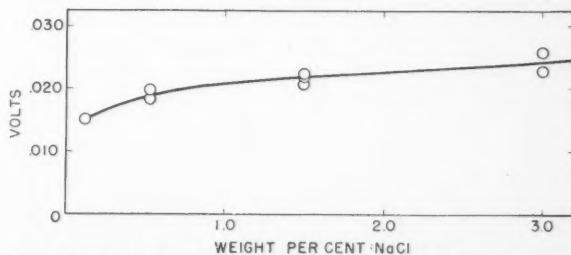


Figure 3—Effect of NaCl concentration on potential difference between 100-degree C steel electrode and 25-degree C steel electrode. (Hot electrode is anode.)

lower value, but this has not yet been checked experimentally.

Current through any cell is determined by the open-circuit potential, by the resistance of the electrolytic and metallic conductors, and by the polarization of the electrodes. Examination of the data, as discussed below, reveals that currents plotted in Figure 4 are evidence of polarization control rather than resistance control. The actual operating cathode potential E_c can be expressed in terms of the open-circuit potential E' as follows:⁵

$$E_c = E' - f_c I / A_c \quad (1)$$

where A_c is the area of the cathode, I is the total current, and f_c is the function expressing the relation between polarization potential (back emf) and current. In some cases, the polarization is approximately linear with current, whereupon f_c becomes a constant. Also since A_c is constant, the following may be assumed to hold as an approximation:

$$E_c = E' - kI \quad \text{where } k \text{ is a constant.} \quad (2)$$

Likewise at the anode:

$$E_a = E'_a + k'I \quad (3)$$

Since the operating potential of the cell E is equal to $E_c - E_a$ and the measured open-circuit potential of the cell E' is equal to $E'_c - E'_a$ we have, combining (2) and (3):

$$E = E' - (k + k')I$$

If R is the electrolyte resistance (the metal circuit resistance can be neglected), Ohm's law provides the following relation:

$$I = [E' - (k + k')I]/R \quad \text{or} \quad I = E'/[R + (k + k')] \quad (4)$$

Therefore, the ratio of E'/I , which is the ratio of open-circuit potential to total current I , provides values of $R + (k + k')$. These are tabulated in Table II.

The fact that $R + (k + k')$ is approximately constant, increasing only for the 0.125% NaCl concen-

tration despite a 19-fold decrease in specific conductivity over that of 3% NaCl solution, is evidence that the polarization factor ($k + k'$) is more important than Ohmic resistance R . The same conclusion is reached from the experimental fact that varying distance of electrode separation during measurement of short-circuit current had no effect on the observed value of current.

Measurements Using FeSO_4 and Discussion of Results

The foregoing results are obtained from potentials essentially irreversible and hence are not amenable to the theory for reversible differential temperature or thermogalvanic potentials.^{6,7} In an attempt to measure reversible potentials, the electrolyte was changed to 0.1 molar FeSO_4 . Data obtained in this electrolyte, however, changed rapidly with time and were extremely sensitive to rate of stirring. The polarity of the cell, and the actual value of the potential depended upon the relative amounts of Fe^{+++} , always present with Fe^{++} , since in the presence of air it was virtually impossible to avoid formation of trivalent iron. Addition of iron powder plus sulfuric acid to reduce the amount of Fe^{+++} shifted the potential from -0.24 volt to $+0.055$ volt but almost immediately the potential tended toward its former value, indicating rapid oxidation of ferrous ion. Qualitatively, whenever the ratio of ferrous to ferric ion was high, the hot electrode at 100°C was the anode, whereas when the ratio decreased, that is ferric ion concentration increased, the hot electrode became cathode. The polarity and magnitude of the potential in ferrous sulfate, therefore, depends on the relative oxidizing or reducing capacity of the electrolyte as well as the temperature difference of the electrodes.

In aerated NaCl solutions, it appears plausible, as already discussed, that the differential temperature currents are controlled largely by polarization effects, and these from what we know of the corrosion behavior of iron, are centered at the cathode. In other words, the increased corrosion of the hot electrode (the anode) caused by coupling with the cold electrode (the cathode) is controlled by the extent of oxygen depolarization at the cathode. One interesting and important conclusion from these results, although not yet proved by actual corrosion weight loss, is that the hot electrode as anode in sodium chloride solutions and arranged as in the cell described above, will cathodically protect the cold electrode. The resulting cathodic current density of 0.43 milliampere per square inch (62 milliamperes per square foot) in 3% NaCl is ample for cathodic protection of the cold electrode in the stirred solution.

In absence of oxygen, differential temperature currents seem unimportant. Proof for this was obtained by setting up a small laboratory cell, using the same U shaped electrodes, but now immersed in 3% NaCl deaerated with nitrogen previously purified by passing over hot-copper turnings. The current on short-circuiting the hot electrode (100°C) with the cold electrode (25°C) was zero. The open-circuit potential, likewise, fell to a low value of variable polarity which averaged out to zero.

Potential measurements of the hot and cold elec-

TABLE II

Values of $R + (k + k')$ in NaCl Solutions

NaCl Conc.	$E'_{\text{Fe}100^\circ - \text{Fe}25^\circ}$	Short-Circuit Current, I	$E'/I = R + (k + k')$
3.00 percent	.024 volt	.0040 amp.	6.0
1.50	.022	.0040	5.4
0.53	.019	.0033	5.8
0.125	.015	.0019	7.9

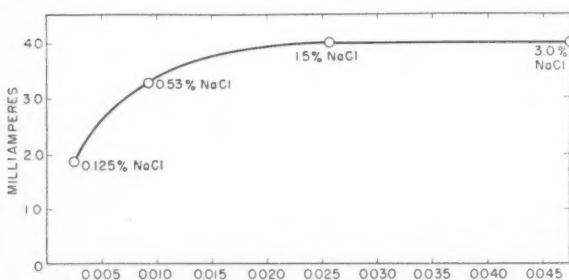


Figure 4—Effect of specific conductivity and NaCl concentration on short-circuit current for 100-degree C steel—25-degree C steel cell. (9.4 sq. in. of each electrode immersed, 2½ inches apart.)

trodes in aerated 3% NaCl versus 0.1N calomel cell, although not carried out in the same detail as in the previous measurements, demonstrated that the potential difference of hot and cold electrodes has its source in the more enabling effect of dissolved oxygen on the cold electrode than on the hot electrode. The initial potentials of hot or cold electrode in deaerated 3% NaCl were approximately the same at 0.83 volt, but on admitting oxygen the cold electrode—calomel cell potential was 0.714 volt compared with 0.748 volt for the hot electrode—calomel cell. This agrees with the conclusion that the potential exists only when oxygen is present, is greater the higher the oxygen concentration, and is essentially an irreversible potential.

Summary and Conclusions

1. The potential of iron at 100° C versus iron at 25° C in 3% NaCl under specific conditions of aeration and stirring is 0.024 volt, with the hot electrode the anode.
2. Decrease of aeration or stirring decreases the measured potential difference. Also in NaCl solutions more dilute than 3%, the potential difference is less.

3. The short-circuit current in aerated stirred 3% NaCl for a 75° C temperature differential in the particular cell used in this investigation amounted to 0.00043 ampere per square inch, which is equivalent to an anodic corrosion rate of 0.03 ipy. In nitrogen saturated solution, this current falls to zero.
4. The short-circuit current is apparently limited by polarization of the cathode rather than resistance of the electrolyte (0.125% to 3% NaCl). It appears that the hot iron electrode, as sacrificial anode, will cathodically protect cold iron to which it is coupled in 3% NaCl solution.

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DISCUSSIONS ARE INVITED

Readers who wish to submit written information additive to articles published in CORROSION, or who wish to register differences of opinion with respect to any articles are urged to send such discussions to Dr. F. N. Alquist, Chairman, NACE Editorial Review Committee, Organic Research Laboratories, 20A Building, Dow Chemical Co., Midland, Mich. Doctor Alquist will submit such discussions to a member of the review committee, and after review and approval the discussion will be published.

The expression of opinions about or the addition of information to that contained in technical articles will advance the interests of NACE and make CORROSION more valuable to the membership.

Corrosion Protection of Power Transformers By Flow Coat Method*

By SIEBERT L. MILLER*

Abstract

This paper will present the results of several years' experience and experimentation with corrosion protection of power transformers as related to the Flow Coat method of applying stripping media and protective coatings. These findings will show the advantages and possible disadvantages with respect to economy of the method from the standpoint of time required for application of the coatings, life of the protection, type of equipment required and other points.

THIS PAPER will present some results of nearly ten years experience and experimentation with corrosion protection of power transformers as related to the flow coat method of applying stripping media and protective coatings.

A description will be given of the method itself, the type of equipment required, and certain techniques employed in the operations.

These findings will show the advantages with respect to economy of the method from the standpoint of time required for application and life of the protection.

Briefly, the economies and other main advantages are:

1. Flow coat painting assures speedy, thorough coverage and an unbroken film on the entire transformer including the inaccessible parts of the transformer radiators.
2. Flow coat stripping assures complete and speedy removal of the deteriorated coating from the entire transformer and particularly the inaccessible parts of the transformer radiators.
3. Both stripping and painting substantially reduce the job time and costs
 - a) Approximately 70% for stripping.
 - b) Approximately 50% for painting.

The terms "flow coat," "Flo-Coat" and "Flo-Coating" refer to a method of paint application now commonly used by equipment manufacturers, which has been especially adapted to maintenance in the field by one of the paint manufacturers. These same terms are also used to designate a method of removing paint.

In flow coat stripping or flow coat painting a continuous stream of material coming from a simple nozzle on the end of a garden hose is directed on the transformer surfaces by the painter. One might say that this is sort of a dipping process in reverse.



About the Author: Siebert L. Miller has been employed by Union Electric Company of Missouri since 1925. After service in substation engineering and supervisory capacities he was named system supervisor of substation maintenance. He also acts as an associate consultant on certain corrosion problems of his company.

Instead of picking up the apparatus to be painted and lowering it into the paint or stripping material, it is left in position and these materials are picked up and literally poured over the apparatus. Certainly the end result is the same because the transformer is as thoroughly covered as if it had been dipped. It is a very simple matter for the painter by means of the nozzle on the end of the hose to direct the spurting stream of paint or stripping media at all surfaces, into crevices, and around all of the tubes of the radiators.

The equipment required for flow coat painting is simple. About all that is required is a motor driven pump of 10 to 20 gpm capacity fitted with a by-pass valve to regulate the flow of paint, some $\frac{3}{4}$ -inch hose, a few $\frac{3}{4}$ -inch pipe fittings, and metal catch pans when required to catch the paint for re-circulation.

The paint used is a long oil type specially prepared so that it will properly flow out and drain without leaving "sags" and "curtains." Not all paints can be flowed successfully.

As to the actual flow coat painting operation, the painter, standing on a scaffold, begins at some convenient point. An assistant starts the pump and adjusts the by-pass valve for the proper flow of paint. This adjustment is important because the success of the method depends on volume and not force. The paint must be flowed and not squirted. The pump raises the paint from a sump at the base of the transformer to the nozzle held by the painter at the top of the transformer. The paint flows down the sides of the transformer into the catch pans and thence into the sump for re-circulation.

No catch pans are used for transformers installed on concrete pads. These require only the placing of lumber around the four sides of the concrete slab and

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sealing with caulking compound. The paint is then allowed to drain on the concrete and is pushed with a squeegee to the drain leading to the sump.

Drops of paint tending to hang on underneath horizontal surfaces and the excess standing on upper horizontal surfaces after the flowing operation are simply blown away with a portable blower or may be quickly brushed off with an ordinary paint brush.

The paint mixture used is quite thin and when poured on the transformer, it all runs off except a smooth unbroken film of proper thickness. The thickness of the mixture must not vary, because if too thick, it will not run off properly, and if too thin, it will run off too freely and leave an insufficient coating. The painter controls the mixture by frequently checking it with a direct reading hydrometer and adding only the amount of thinner required to maintain the gravity specified by the paint manufacturer. During warm weather or on a windy day more thinning is required than on a cool still day. It is, therefore, very important that gravity readings be taken at frequent intervals and just the right amount of thinner be added to compensate for loss by evaporation. We have found that for best all around results the painting should be done when the outdoor temperature is above 50° F and below 95° F. Within these temperature limits, the range of specific gravity should be approximately as follows:

Primer	1.15 to 1.25
Intermediate Coat	1.10 to 1.20
Finish Coat	1.00 to 1.10

More satisfactory results have been obtained using oleum spirit thinners than naphtha because of their slower evaporation permitting more accurate control of the paint thickness. Naphtha also presents much more of a fire hazard.

The flow coat method of painting was first recommended to us by the James B. Sipe Company which gave us considerable counsel and technical advice in selecting proper equipment and adapting the method to our field maintenance work. This method of painting was initially tried by our company at the Cahokia Power Plant in 1937. From our experience there we adopted the method for two major reasons: First, and most important, it assured complete coverage and an unbroken film of paint on the transformer radiators, thus providing more adequate protection than other methods; and second, it substantially reduced the job time and cost. In most cases this reduction amounts to more than 50%. The reduction in job time alone is very important because operating requirements today are usually such that the transformers may be taken out of service only for short periods at selected times.

As to the quality and life of the protection afforded by this method, we have three transformers at Hi-Pointe Substation and two at Northland Substation which were painted nearly ten years ago and are still in good condition.

Three coats of paint are applied when repainting requires complete removal of the remaining old painted surface. A three-color system is used so that as the finish coat slowly "chalks" off it exposes the

intermediate coat of a lighter color and finally the red primer coat thus giving a warning before the bare metal is exposed. If the transformer is painted at this time no stripping is necessary and only two coats of paint are required.

When the paint job is delayed until rusting has started, it is not only necessary to completely remove the old paint but the rust must also be dealt with. A re-paint job of this kind costs more than twice that of one done before the primer coat has deteriorated.

Formerly we applied the paint with a spray gun which was all right for the top and main tank. However, it was absolutely impossible to properly cover all surfaces of the radiator tubes because of their being so close together and assembled to the headers in staggered arrangement. We experimented with many different spray heads, some of our own special design, and found that none of them would apply a uniform coating. This was because the spray, when directed into the maze of tubes, would lose its force, becoming just a fog which settled out on the tubes in a film resembling a coat of paint, thus making it impossible to determine if the tubes were properly coated. This provided no corrosion protection whatever because by the time it settled on the tubes it was practically nothing more than pigment minus all the vehicle.

The mist or fog from a spray gun also presents another problem, as many of you know, because it settles out on porcelain insulators and bushings of nearby apparatus and other equipment and "foreign" objects, such as parked automobiles, all of which have to be washed and cleaned.

The radiator tubes of two transformers removed last year from our McKnight Substation were found to be rusted rather extensively which necessitated complete stripping and re-painting of both transformers. Both had been previously painted with a spray gun. Nothing less than a very close inspection disclosed the rusted condition on the back sides of these tubes because all other surfaces exposed to view appeared in good condition. Fortunately these transformers are equipped with radiator tubes of heavier than normal gauge metal and the rusting had not progressed far enough to endanger the safety of the tube walls.

The difference in time required for spraying and flow coating the paint on a transformer is impressive both from the standpoint of painting manhours and out-of-service time for the transformer. Spray painting a transformer equipped with radiators requires, on the average, double the manhours required for flow coating the same transformer and, as mentioned before, the end result of the spray painted job is unsatisfactory. As an example, one of the transformers at our Lesperance Substation which had to be "stripped" and repainted required 18 man days for application of three coats of paint by spray gun method. This job required several different types of specially designed spray heads and a small mirror in an effort which later proved futile, to completely coat the inaccessible surfaces of the radiator tubes.

Application of three coats of paint to this same type transformer by the flow coat method required about nine man days or about half the time required for

spray application. Typical of all flow coat jobs, most of this time was required for setting up the scaffolding, painting equipment, catch pans, sump, mixing of the paint, and other preparatory work. The actual flow coat painting operation itself required only about 25 minutes for each coat.

There is also a substantial difference in the amount of time a transformer is required to be off the load or out of service while spraying or flow coating. Again using the Lesperance transformer as an example, it was out of service for about six painting days or 48 hours for the spray job.

The maximum required for the same three-coat job by the flow coat method is about two hours on each of three days or a total out-of-service time for the transformer of about six hours. This represents only the time required to paint the top of a transformer having exposed live bushing terminals. The main body, radiators and other surfaces below the top, are painted with the transformer remaining on load.

Another application for flow coating which we are planning and which may be of interest to some will effect substantial savings in the painting of transformers for our downtown AC network system. The transformers are located in vaults below the sidewalks and many of them are loaded above their self-cooled rating which necessitates water spray cooling. This has accelerated the paint wear and rusting has now started so that a complete stripping and re-painting job will be necessary for proper protection.

Application of the paint by spray gun is out of the question because of inadequate clearance between the transformers and the side of the vault, and even if there were sufficient clearance, the radiator tubes could not be uniformly coated because of their arrangement.

Repainting the transformers in the shop would involve considerable expense in addition to the painting job because each would have to be disconnected and removed from the vault and then re-installed and connected after painting. A job of this kind would cost about \$310.00 for each transformer.

Flow coating will be done in the vaults with the transformers remaining on load. By using this method the job can be done at a cost of \$190.00 for each transformer.

Flow coating need not be restricted to the corrosion protection of transformers. We have found it economical to apply the method to the painting of chain link fences. In some cases the cost of the flow coat job was less than a third of the cost for a hand brush job and in all cases there was more thorough coverage with the flow coat method.

We adopted the flow coat method of stripping, after first trying it at our Page Station in 1939, for the same reason that we adopted flow coat painting. First, and most important, it assures complete and thorough removal of the old paint from the transformer radiators. Second, it substantially reduces the job time and cost.

Stripping and painting operations are quite similar although some additional equipment is required for the stripping work. The essential parts of the stripping

outfit are a large oil-fired heating kettle of about 160 gallons capacity, two centrifugal pumps, $\frac{3}{4}$ -inch hose, metal catch pans and a suitable spray head for directing the stripping solution to all surfaces.

Best results are obtained when the solution, which is a caustic alkali with a wetting agent added, is used at a temperature of 175° F. It is, therefore, necessary to provide a heating vessel of sufficient heating capacity that the stripping solution can be maintained at this temperature.

One of the pumps is required to raise the solution from the heating kettle up to the spray head and the other pump is used to return the solution from the sump to the kettle for re-heat. For the latter we have found that a regular cellar drainer type pump equipped with a float switch serves the purpose best.

The stripper is handled in much the same manner as the paint: the same catch pans are used for collecting and diverting to the sump and the solution is recirculated.

After all paint has been removed, the surfaces are flushed with a hot weak solution of phosphoric acid to neutralize what remains of the stripping solution. This washing solution is prepared by adding 5 per cent commercial phosphoric acid to water and is applied to the transformer at a temperature of 190° F. This higher temperature further expands the pores of the metal thus assuring a more thorough neutralization of any remaining alkali. After this treatment the surfaces are thoroughly flushed with clear water and, of course, the primer coat is applied just as quickly as possible after the surfaces are completely dried before any rusting starts.

A stronger phosphoric acid solution is used at times to actually etch the surfaces of some transformers because the metal was not properly prepared for painting at the time of fabrication. In addition to etching the surface into a matte, this treatment provides some chemical inhibiting action against rusting.

The former methods of paint stripping were all right for all surfaces except the transformer radiators. The same difficulty was experienced in stripping as in painting, that is, too many surfaces could not be reached with the stripping solution.

One of the best previous methods we employed in paint stripping used a hot strong solution of caustic alkali with starch added. When applied to the transformer surfaces the starch would rather quickly congeal, holding the stripping media in contact with the old paint. In some cases, with this and other methods previously tried, it was next to impossible to completely remove all of the old paint from the transformer radiator tubes. Only after long and tedious effort was this possible. On the average it required about 12 man days to strip a transformer by this method. In a few cases the stripping labor extended to more than 15 man days.

Using the flow coat stripping method we now do the job in a day or less requiring only 4 man days of labor. The old stripping method required that the transformer be off the load for 24 to 40 hours in a period of 3 to 5 days. The present flow coat method never requires more than 8 hours out of service for

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Summary

The flow coat method of corrosion protection of power transformers is fully justified economically and offers other specific advantages.

Adequate protection impossible of accomplishing

with other methods is fully realized with flow coating.

It takes the guesswork out of paint reduction in the field and assures a uniform film of proper thickness.

Workmen much prefer flow coating to spray or hand brushing methods.

The absence of mist or fog precludes the necessity for cleaning work required after spraying and makes it unnecessary for the men to wear respirators.

The Value of Backfill With Carbon and Graphite Anodes*

By J. P. OLIVER* and W. W. PALMQUIST*

THE EFFECTIVENESS of cathodic protection, whereby an impressed current is applied to metal to make the latter cathodic to its environment and thus to counteract corrosion, is well established. With corrosion losses of iron and steel costing American industry well over a billion dollars per year,¹ interest has naturally centered on this means of protecting buried or submerged metal, in pipe lines, power plants, refineries, chemical plant equipment, water tanks and the like.

A typical circuit using a rectifier and carbon or graphite anodes for this purpose is shown in Figure 1. In operation, current flows from the rectifier or other DC source progressively through the anode conductor and anode, through the anode's environment or backfill into the earth, thence to the metal structure, returning to the negative side of the rectifier over the negative conductor. The current opposes the anodic solution of the metal and, in addition, creates an alkaline environment at the metal surface, which may further reduce the tendency to corrode and may afford temporary protection if current is interrupted.

The function of the anode is simply the introduction of current into the ground. It is, of course, desirable to accomplish this in the most effective manner considering installation cost, life and dependability.

Carbon and Graphite Anodes

In a cathodic protection circuit, carbon and graphite function as insoluble anodes with the liberation of oxygen at their surfaces, and therefore at the potential of oxygen discharge. They can, of course, be oxidized electrochemically, but even in the worst case, if all the anodic current were to form carbon dioxide, it would take 4050 ampere-hours to consume one pound of carbon as compared with 1352 ampere-hours per pound for aluminum and only 435 ampere-hours per

pound for iron. Under usual operating conditions because oxygen, as stated, is the principal product, actual consumption of carbon and graphite anode rods will be considerably less than indicated theoretically, and even this can be further reduced by special types of waterproofing impregnation and the use of suitable carbonaceous backfills.

In general, graphite anodes are more resistant to electrochemical oxidation than carbon, the latter being preferred only when bromides or fluorides are present to an appreciable extent.

Value of Backfill With Carbon and Graphite Anodes

The carbonaceous backfills developed by the authors' company have been designed with the following purposes in mind:

1. Lowering anode-to-soil resistance.
2. Prolonging life of anode by transferring electrochemical attack from anode to backfill.
3. Allowing a greater current carrying capacity without materially reducing anode life.

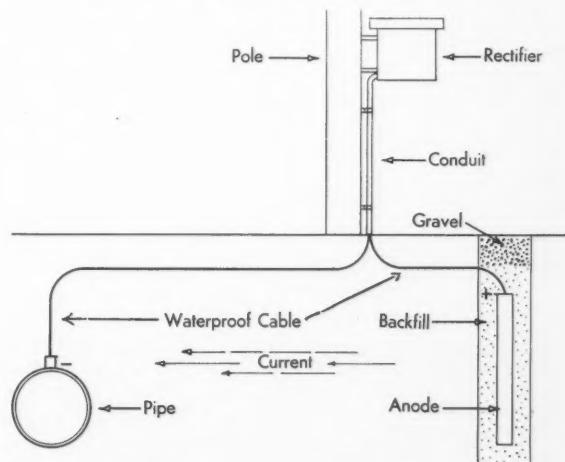


Figure 1—Schematic diagram of a cathodic protection installation.

*A revision of a paper presented by J. P. Oliver at South Central Regional Meeting, National Association of Corrosion Engineers, Tulsa, Oklahoma, September 20-21, 1948.

¹National Carbon Division, Union Carbide and Carbon Corporation, New York, N. Y.

Fundamentally, they consist of granular forms of carbon or graphite which are good electrical conductors, thereby assuring the proper electrical contact with the anode and with the soil. Since graphite has a greater resistance to electrochemical oxidation than carbon, a graphite particle backfill is generally more desirable than one of carbon particles. The addition of alkaline materials (such as lime) has been found advantageous,² since such materials decrease the rate of electrochemical attack, lower the oxygen discharge potential, increase moisture retention and improve the uniformity of the carbonaceous backfill. The most desirable backfill for long life and efficient service is, therefore, a graphite particle environment to which alkalinizing materials have been added.

Lowering Anode-to-Soil Resistance

A proper carbonaceous backfill will provide metallic-type contact with a carbon or graphite rod, and in addition, a more intimate contact with the surrounding soil than is possible in the case of smooth rod or plate alone. As a demonstration of this effect, the following laboratory test is cited:

A glass-lined box, 6" by 6" by 14" (inside dimensions) was provided with a steel plate at each end, as shown in Figure 2. These plates were used as cathodes, each having a directly exposed surface of 36 square inches. Six inches from one end, a graphite plate, 1" thick, was placed to be used as an anode. The faces of the anode were parallel to the cathode plates at each end, and the effective area of the anode was 36 square inches on each side. On the side of the anode that was 7 inches from the cathode plate, a 1" vertical layer of plain graphite particles (no alkalinizing materials added) was placed, to function as a backfill. The remaining volume on each side of the anode, a space 6" by 6" by 6", was packed with wet clay. A direct current with a voltage of 8.9 was

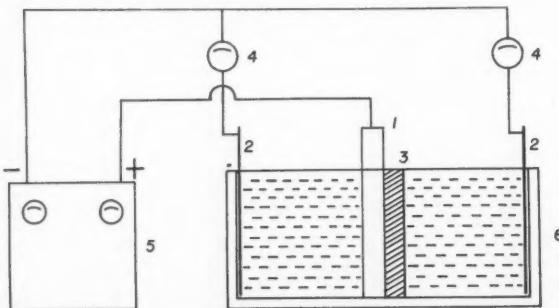


Figure 2-1—Graphite anode, 1-inch thick. 2—Steel cathode sheets. 3—Backfill of graphite particles. 4—Milliammeters. 5—Rectifier. 6—Glass-lined cell box. Volume of clay on each side: 6" x 6" x 6".

impressed upon the anode. Each side of the circuit carried 140 milliamperes at the outset. Shortly after the current was applied, the side without the backfill increased its output to 145 milliamperes. After 15 hours of operation, with the same applied voltage of 8.9, the side with the backfill was carrying 124 milliamperes (circuit resistance 71.8 ohms) and the other side, without a backfill, was carrying only 104 milliamperes (circuit resistance 85.6 ohms). In this case the side with the backfill was carrying nearly 20% more current.

When backfill is installed surrounding a carbon or graphite anode in a vertical hole, the resistance between the anode and earth will be decreased because of the increased area of contact provided. In effect, the low-resistance backfill extends the effective anode diameter to the outer diameter of the backfill, thereby decreasing resistance in accordance with Dwight's equations.³ Figure 3 is a nomograph giving the approximate resistance between individual carbon or graphite anodes and remote earth based on these equations. It will be seen that this resistance is affected not only by the anode size and soil resistance, but also on whether a carbonaceous backfill is used.

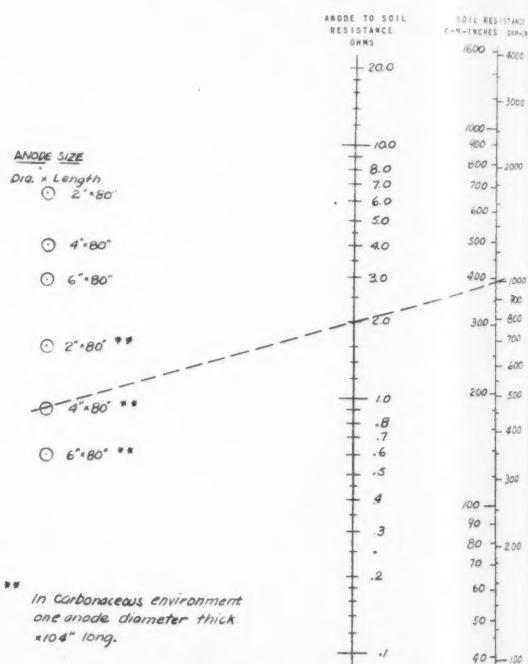


Figure 3—Resistance of single vertical graphite ground anodes to remote earth. (Note: For soils with resistance higher than shown, divide soil resistance by multiple of 10 and multiply anode-to-soil resistance read from chart by that factor.)

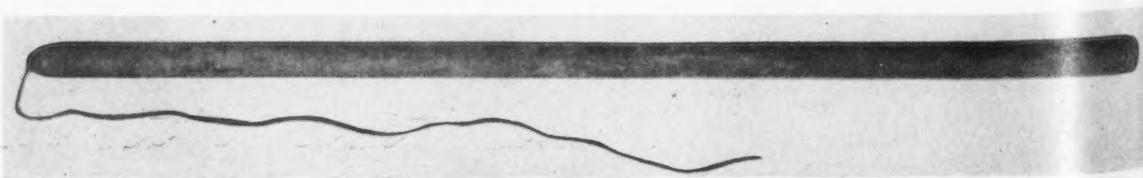


Figure 4

When calculating the value of impressed voltage required to overcome the resistance from anode to earth as shown in Figure 3, the potential required for oxygen discharge at the carbon or graphite anode must be added to the calculated voltage. This potential will vary from slightly under 1 volt for alkaline conditions to about 1.3 to 1.6 volts for acidic conditions.

Example: What voltage is required to pass 5.0 amperes from a vertical 4" diameter x 80" long graphite anode in carbonaceous environment 12" diameter x 104" long to 1000 ohms-centimeter soil?

Solution: From Figure 3, the approximate anode-to-soil resistance will be 2.0 ohms. To pass 5.0 amperes, $5 \text{ amperes} \times 2 \text{ ohms} = 10 \text{ volts}$ will be required. If an alkaline backfill were used, the total voltage required (including oxygen discharge potential) would be 10.0 plus 1.0 or about 11.0 volts. Without an alkalizing medium in the backfill, 10.0 plus 1.6 equal 11.6 volts would be necessary, since the anodic reaction normally promotes an acidic anode environment.

Prolonging Life of Anode

In a proper installation, the carbon or graphite electrode is primarily a conductor to the carbonaceous backfill, the latter serving in large part as the active anode, and bearing the brunt of the electrochemical attack. Thus ion discharge at the rod is effectively reduced and useful life is correspondingly extended. Specifically, the life expectancy of carbon or graphite anodes in a carbonaceous backfill may be from five to twenty times the theoretical value of 4050 ampere-hours per pound, or of the order of 20,000 to 80,000 ampere-hours per pound. On this basis, a 20 pound carbon or graphite anode in backfill would be completely consumed only after handling 5 amperes continuously for 10 to 30 years.

The 2" x 80" graphite anode shown in Figure 4 was recently removed for examination after operating for nine years in a lump coke backfill. Continuous current discharge from the anode was approximately 1.5 ampere or a total of 13.5 ampere-years. Actual consumption of the graphite rod was about 2 to 3 pounds, which is the equivalent of 40,000 to 60,000 ampere-hours per pound. In this instance, if the rod were to be removed from service when half consumed, graphite cost would amount to .0022 cents per ampere-hour or about \$0.20 per ampere-year. If removed when $\frac{2}{3}$ consumed, graphite rod cost would be only \$0.15 per ampere-year.

The amount of backfill for proper proportioning of current discharge and carbon consumption between the anode and backfill is discussed later under "Installation." In each case, this provides a backfill thickness equal to the anode diameter and extending at least one foot beyond the upper and lower ends of the anode.

Greater Current-Carrying Capacity

As shown by Figure 3, a greater current output per anode for any one impressed voltage is made possible by decreased anode-to-earth resistance when a backfill is used. In addition, through the higher permissible total current made possible by the increased active anodic

surface provided by the backfill, a maximum current density on the anode rod surface proper of 1.0 ampere per square foot is permissible for carbon or graphite anodes operating in a carbonaceous backfill of the approved type for a nominal 10 years life. Without a backfill, an anode rod surface density of only 0.25 ampere per square foot maximum is recommended. On this basis, the total recommended currents for commonly used carbon and graphite anode sizes are shown below:

TABLE I
Recommended Anode Currents

Anodes 80" Long Diameter, (Inches)	With Approved Backfill or in Salt Water (Amperes)	Without Backfill or in Fresh Water (Amperes)
2.....	3.5	0.9
4.....	7.0	1.8
6.....	10.5	2.7

To emphasize the advantages of a carbonaceous backfill from a practical standpoint, reference is made to data from a test ground bed containing anodes operating both with and without such backfill. The test bed originally contained:

TABLE I

Designation	Quantity 80" Anodes	Dia., (Inches)	Type	Backfill	Hole Dia., In.
A.....	4	4	Graphite	Soil	4
B.....	4	2	Steel	Calcined coke breeze	6
C.....	4	2	Graphite	Calcined coke breeze plus lime	6
D.....	4	2	Graphite particles	Graphite particles	6

Anodes were located on a 15-foot straight line spacing in soil of 800 to 1000 ohm-centimeter resistance. The various designations were arranged in order ABCDABCDABCDABCD so that in obtaining average readings for each type of anode, any interference effect because of location would be more or less cancelled. Readings of anode current and voltage impressed were taken for each individual anode every month during the two years test.

After one year's operation, one of each anode designation was removed for examination. The remaining twelve anodes operated for an additional year, after which four more anodes (one of each designation) were examined. Data on the two years' operation are summarized below:

TABLE II

80" Anodes Dia., (Inches)	Type	Backfill	End of First Year (Applied Voltage 3.79) Average Current Amperes	End of Second Year (Applied Voltage 5.42) Average Current Amperes
4"	Graphite	Soil	.255	.455
2"	Steel	Coke breeze	.436	.628
2"	Graphite	Coke plus lime	.537	.842
2"	Graphite	Graphite	.530	.823

Figure 5 is a photograph of the four anodes removed at the end of the second year. Note the clean, square ends of the 2" x 80" graphite anodes operated in carbonaceous backfill, the rounded and porous end of the 4" x 80" graphite anode in natural soil alone and the jagged end and pitted appearance of the 2" x 80" steel anode. On the latter, necking had occurred and loss of electrical contact would have been probable in another year or two.

The tentative conclusions from the two years' operation described are that the resistance to ground of steel anodes in carbonaceous backfill is higher than graphite anodes in comparable installations; and that at relatively low current densities, actual consumption of graphite anodes in carbonaceous backfill is minute compared with the theoretical, while attack of graphite anodes installed without backfill is perceptible but still less than theoretical.

Field observations over a long period of time have indicated that the greater current-carrying capacity and longer life afforded by the use of recommended carbonaceous backfills more than offset the added cost of backfill for the original installation. One bed of graphite rods without backfill was examined recently after four years of service with an average current density of 0.44 ampere per square foot of anode surface. These anodes had shown no increase in resistance, but the surfaces of the rods examined were soft, indicating electrolytic oxidation. As shown in Figure 4, recent examination of a carbon anode ground bed after nine years of service with an average current density of 0.43 amperes per square foot of anode surface showed the rods to be quite firm with little evidence of attack. The rods had been installed in a coke backfill within a 6-inch diameter hole. The coke also showed little evidence of attack.

Installation

When installing graphite or carbon anodes in a vertical position, the carbonaceous backfill used should extend at least one foot above and below the anode. The thickness of the backfill material surround-

ing the anode should be a minimum of one anode diameter, with an initial hole size of at least three anode diameters. For commonly used carbon and graphite anode sizes the following volumes and weights of backfill are suggested:

TABLE IV

Anode Size, (Inches)		Min. Vol. Backfill Cu. Ft.	Weight Backfill, Pounds
Diameter	Length		
2.....	80.....	1.74	105
4.....	80.....	6.24	368
6.....	80.....	14.33	845

* Based on alkaline graphite particle backfill. For other types calculate weight from weight-volume relation applying.

Little difficulty should be encountered in the proper installation of anodes in the backfill. A portion of the backfill is placed in the hole and the anode centered therein. The remaining backfill is then added, taking care to tamp or settle the backfill around the anode at intervals to insure good contact with earth. If the hole into which the anode is to be inserted is filled with water, the water should be pumped out or displaced as much as possible before proceeding; otherwise, the backfill can be made into a heavy slurry with water and slowly poured into the hole to avoid loss by flotation. Where soil conditions permit the use of shallow holes only, backfill may be used to surround shorter anodes placed vertically or horizontally.

Conclusion

The inherent advantages of graphite and carbon material as anodes for cathodic protection installations are increased from a practical standpoint by the proper selection and use of backfill material. A suitable carbonaceous backfill will effect:

1. Lowering of anode-to-soil resistance.
2. Prolonging life of anode and transfer of electrochemical attack to backfill.
3. Greater current-carrying capacity.

These advantages have been substantiated by laboratory and field work, and there is every indication that

for proper economy in operation of a cathodic protection system, the use of the proper type of carbonaceous backfill with graphite and carbon anodes is most desirable.

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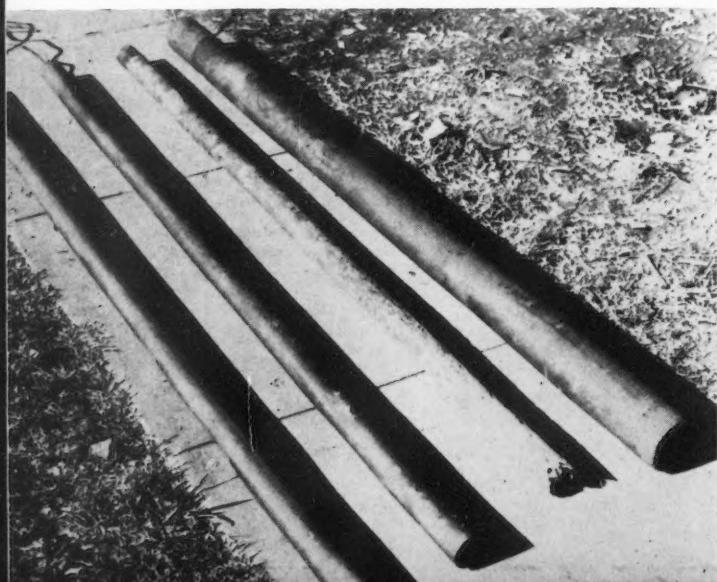


Figure 5

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Surface Preparation Values And Sandblasting Economics*

By A. J. LIEBMAN*

Abstract

This paper aims to show how surface preparations can be dependably and economically determined beforehand, and the total performance value of coatings either increased or decreased, depending on service requirements. An outline of all suitable surface preparation methods will be given although the main emphasis will be on preparation by sandblasting. Metal can be sandblasted by the dry or wet process in either an open or closed system. Present limited use of proper terminology and good selective interpretation of blasting work develops costs that can range from 5c to 40c per sq. ft. There is a need for some fluctuation, but in many cases greater initial economy is possible if real needs are understood. To properly interpret such needs, distinct practical dividing lines for blast finish classifications must be found. Presently, it is said "blast the surface and prepare for paint application." One operator interprets this as a job that can be covered at the rate of 350 ft. per hour; and another operator, at the rate of 100 ft. Because of this ambiguous meaning, many a blast job has to be done over. In other cases, a high priced job involves the removal of all scale and binder to the white metal which requires approximately one hour blasting per 100 sq. ft., yet the coating could have performed as well with the less costly removal of mill scale only. Further value is placed on blast sand selection. Some sands produce a high initial breakdown. The ultimate production and surface quality depends largely on well selected sand. Sand grain size is also important, especially where a thin coating is contemplated. With present labor costs, equipment can mean the difference between success and failure on a job. The paper touches on the importance of equipment which will dependably help to reduce the overall cost in sandblasting.

COATINGS of various types have contributed to the preservation of the steel mass that is used in the construction and fabrication work of this modern world. Without coating protection, the annual losses due to corrosion would be considerably higher than the present world-wide estimate of 6½ to 10 billion dollars.¹ A recent estimate by H. Uhlig shows that corrosion losses and its controls, mean an annual expenditure of 5½ billion dollars in the United States, both for industry and the Government.²

In order to apply coatings properly and to receive from these coatings the maximum of service life and reduce their deterioration to the pure mechanics of a natural breakdown due to surface losses, any coating must become as nearly an integral part of the metal as is possible within the limits of the coating's adherence characteristics and the cost economics covering the specific product.

One cannot discuss surface preparation of any sort unless one defines its relative value to specific characteristics of a coating.

While a coating can be defined in many ways, the

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definitions important to surface preparation selection can be classed as follows:

1. Wetting strength or wetting depth of a coating.
2. Wetting time of a coating.
3. Surface tension of a dry coating.
4. Adhesion characteristics.
5. Bonding characteristics.

(See Appendix for legend on characteristics of Items No. 1 to 5, inclusive.)

When all five of the aforesaid characteristics are fully known, suitable specifications can be written on surface preparation for a satisfactory and economical coating tie to the metal.

For the purpose of this paper, let us set up three specific value variations for each of the five aforesaid characteristics.

1. High, medium, and low wetting strength.
2. High, medium, and low wetting time.
3. High, medium, and low surface tension.
4. High, medium, and low adhesion characteristics.
5. High, medium, and low bonding characteristics.

(See Appendix for legend on characteristics of Items No. 1 to 5, inclusive.)

Proper selection of these five variable characteristics must be made after the service conditions under which the product must perform have been fully studied and analyzed. A suitable surface preparation must then be tied as a unit to the service and to the coating combination.

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*Dravo Corporation, Pittsburgh, Pa.

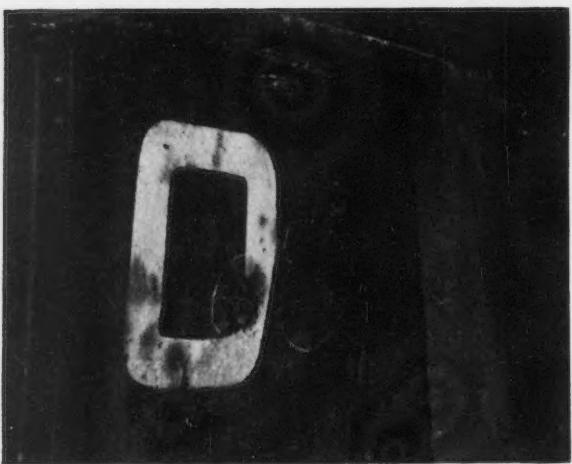


Figure 1—Impact damage to paint on a steel surface which was improperly prepared. A bonding type paint with high surface tension was used on a mill-scaled, wire-brushed surface. A sandblasted surface and low surface tension paint would have prevented this damage.



Figure 2—After 12 months' service, this corrosion damage was noted, even though the steel had been painted with a high priced paint. Cause of this condition is improper surface preparation and coating selection.

Example I

Paint can be applied to a surface covered with mill scale if that product operates under atmospheric exposures. Powerbrush or flame cleaning can be used as a surface preparation. A coating of high adhesion, medium wetting characteristics should be selected.

However, if this same product must operate under surface impact and very active vibrations, the paint should be applied to a surface which was prepared by commercial sandblasting, pickling, or some other process which exposes the pure metal to the paint. Thus a more homogeneous connection is possible, and the scale cannot split or otherwise damage the paint film from within. (See Figure 1.)

Example II

If we select a mill-scaled, powerbrushed surface, and apply a paint with pure mechanical bonding charac-

teristics, we can look forward to a paint job that will peel and lose its intended protective value right at the metal interface. The proper specification would have called for either a paint with good adhesive qualities, or if some other chemical resistance was required which is not inherent in a suitable adhesive coating, an adhesive tie coat should have been specified to be applied between the metal and the first coat (bonding type). A chemical bond can be established between the adhesive and bonding type paints. However, the optimum results will be obtained if a pickled or blast cleaned surface were specified. (See Figure 2.)

For full utilization of our knowledge of coating characteristics, we must also be fully informed of all available processes that will suitably prepare a metal surface for a specific service.

Conventional surface preparation methods and processes can be classified as follows:

1. Weathering and removal of corrosion products.
2. Powerbrushing and other mechanical power cleaning of scale-active steel.
3. Pickling or chemical etching of surface.
4. Flame cleaning.
5. Blast cleaning.

Surface grinding, electrolytic pickling, and centrifugal hammer cleaning, should be mentioned as three additional processes for surface preparation. No description is given due to their present limited practical and economical use around general work.

Steel weathering is one of the oldest methods known in surface preparation work. Its selection is of value only if all other methods must be ruled out by the paint applicator. In weathering, the mill scale is loosened by the natural weathering corrosion process and either the hand or the power wire brush method is generally used to remove all loose corrosion products from the surface. Whenever this method must be employed, a paint with a long time and high wetting characteristic must be selected for economical end results. Paint should be the adhesive type and must possess low surface tension. Cleaning rates for weathered steel surfaces are difficult to establish within a narrow limit and conditions can show variance from 100 to 1000 sq. ft. per man hour of operation. A weathered surface should be cleaned with a solvent before applying paint. Ninety-day weathering in an industrial atmosphere will generally remove most of the mill scale. Metal losses in 90 days due to weathering, will be slightly higher under low humidity than when a surface is blasted. If steel weathers in an atmosphere of high humidity, metal losses in 90 days can reach three times that of the metal removed by blasting.³

Powerbrushing of a mill scale active steel surface is accepted by industry as good standard practice. The wire bristles of the brush are intended for speed removal of all loose scale and rust products. If conscientiously carried out, loose and semi-tight scale can be removed with this method. However, the application pressure and centrifugal force also create a polishing action on a powerbrushed surface. The selection of a coating must therefore possess high steel surface adhesion, medium wetting strength, and medium wetting time characteristics. The coating surface tension should be from medium to low. Wire

istles will distribute (smear) undesirable products over a wide area. It is therefore found advantageous to clean wire brushed surfaces with carbon tetrachloride, perchlorethylene, or other fast-drying cleaning solvents before the paint is applied. Tack rags must be kept clean to prevent smudge carry-over.

Cleaning rates for good wire brushing on the average scale covered steel, approximates 850 sq. ft. per hour. To this must be added solvent cleaning of the surface at 1200 sq. ft. per hour.

Flame cleaning employs an intensely hot-brush-like flame that is rapidly passed over the metal to be descaled.⁴ The thermal gradient through metal and mill scale and the difference in expansion coefficient act to cause the loose, and some of the tight scale, to split off. Corrosion products are similarly affected. On some work, this process has been found desirable, since it has the unique advantage that the local heat reduces the moisture film on the metal surface. One can take advantage of this perfect drying by applying a coat of primer or paint to the metal before any new moisture can attack the surface.

Experience with the process indicates that it is best to follow a flame cleaning operation with a power brush in order to remove the partially loosened or upturned scale particles.⁵ Steel plates that can be flame cleaned range in thickness from 3/16 inch and upward. On lighter sections, cleaning must be sufficiently speedy to prevent any possible warpage from local overheating.

Operational cost is approximately 50 percent that of white surface sandblasting.⁶ Structural shapes can be cleaned at the rate of from 3 to 5 tons per hour. Paint suitable for flame cleaned steel should have medium to high adhesion, low surface tension, medium to high wetting strength, and medium to high wetting time characteristics.

Pickling or chemical etching of steel plates in an acid bath removes scale and rust from the surface chemically. It is common practice to submerge the steel stock or fabricated product into a vat of 5 percent to 15 percent solution of hydrochloric, sulphuric, or phosphoric acid, holding it there for sufficient time at an elevated temperature to produce a scale-free product. It also produces a surface anchor that is very desirable for good paint adhesion. The acid treatment is followed by a water rinse in order to remove acid deposits that may be held and remain active on the steel after painting.

In some cases, the water rinse is followed by a phosphoric or chromate inhibitive bath, which will prevent ferric oxide formation before paints or other rust preventive sealers are applied.

When grease, oil, or other products are present on the surface, and cannot be readily removed with an acid bath, a solvent cleaning bath should be employed ahead of the pickling operation.

Acid etched surfaces are found suitable for coatings of practically any characteristic and some combinations thereof. The surface anchor permits bonding as well as adhesion, and produces added area for a good coating reinforcement.

Chemical cleaning is naturally limited to work which can be readily handled in and out of the acid

tanks. Production per hour varies considerably and must be based on handling facilities and volume, beside the specific treatment itself. For large volume production, it is economical at any rate.

Blast cleaning of steel should be described under several sub-classifications, since its use or selection is dependent on location, size and shape of product that must be cleaned, and the equipment that has been selected for cleaning. For the purpose of this paper, we are making the following divisions:

1. Indoor production-run blasting with steel grit and shot.

2. General blasting using sand.

Indoor production-run blasting with steel grit or shot employs, as the name implies, steel grit or shot of specific grain size, which is discharged through a nozzle outlet of specific size at a predetermined pressure, thus creating steel particle velocity which produces sufficient impact and abrasion to remove mill scale, corrosion, and other undesirable products from steel before protective coatings are applied.

Subject blast materials are also used in the wheel or rotor type machine, where a revolving wheel or rotor products the shot impact velocity, which, in turn, is directed against steel products that must be cleaned by an automatic process.

The reduced breakdown of steel grit and shot during a blast operational cycle permits its economical reclaiming and recirculation from 250 to 1000 times, depending on the type of shot and grit selected. As a general rule, subject blast materials are used on indoor humidity-controlled blasting operations. High moisture content in the air stream causes early rusting of the steel blast particles, which often results in "balling" up or rusting together of considerable volume of the material, thus developing equipment choking or operational troubles.

A surface prepared with shot and grit blasting produces a good foundation for any type of coating and service characteristic. However, the selection or combination of grit and shot must not produce high and sharp points on the anchor pattern, which cannot receive a sufficient coating thickness to offer good and adequate protection for service intended. Also, deep sharp pits in the anchor will cause paint bridging, unless a paint with high wetting strength and long wetting time is used.

If a mastic or an extremely heavy coating is applied, sharp points or pits are acceptable, providing, naturally, that the coating is formulated for deep wetting. The blast anchor pattern on any surface should never exceed 33 1/3 percent of the total thickness of the coating.

General blasting using sand, can be classified under four specific systems:

1. The open dry system.
2. The closed dry system.
3. The open wet system.
4. The closed wet system.

The end results and costs per specific surface condition obtained varies but slightly with the different systems. An outline is therefore limited to apparent advantages which are considered of importance.

The open or closed wet systems permit the inclu-

sion of inhibitors in the water or vapor of the system. If inhibitors are to be used, this advantage will be found of value.

There is continuous dust formation in conjunction with blasting. The wet system will subdue or eliminate this dust hazard. With the average dry blasting operation, very little of this dust will deposit on a surface, and if it does, it can be readily blown off with an air hose. When using the wet system, this fine dust accumulation must either be rinsed with water or brushed off. The added drying time with a wet blast system is often undesirable.

Selection of a blast system must therefore be based on overall advantages for a particular job, and no set rule can be laid down in this paper.

For average operations on commercial blasting work, two items are very important.

1. A dependable satisfactory surface condition.
2. Low costs to produce that surface.

Item 1 should be established by coating characteristics, and the service for which the product is intended.

Item 2 is very important under our highly competitive economy.

The average customer is interested in a paint job that will protect his product for a reasonably long period of time but he is also interested in buying this paint job at a low and mostly competitive cost. It becomes necessary to establish usable tolerances for service preparations in the same manner as you would specify a coating thickness as "from 4½ to 5 mils." You do not want 3 mils because you would receive insufficient thickness, and you do not want 7 mils because you would in most cases increase your costs uneconomically.

A sandblasted surface preparation cannot be established purely by depth of anchor pattern, but more accurately by specific conditions that are established through the use of a specific grain sand.

Surface conditions that are presently established

by sandblasting can cost the customer 5 cents to 40 cents per sq. ft., and unless the blasting operation is done on a time and material basis, either the operator or the customer can sustain unjust losses. Also included in this cycle will be the paint manufacturer who is the victim of circumstances, but who should have done something about the problem a long time ago.

It is apparent that a poor blasting job will remove an insufficient amount of rust and scale products. The use of too large a sand grain size will leave an anchor pattern that is wholly unsuitable for the job and long paint life.

A good surface condition and low cost (per paint life) for the system can be developed in the following manner.

Arrange surface conditions to specific limits, and arrange divisions that can be defined, understood and easily obtained. The blast finish of a steel surface can be separated into three specific categories

1. White surface blasting.
2. Commercial surface blasting.
3. Sand brush-off blasting.

White surface blasting includes the complete removal from steel of all corrosion products, as well as all loose and tight mill scale. The grey oxide binder between scale and steel is also removed. The end result produces a white steel surface with an anchor pattern for good paint adhesion or bonding. (See Figure 3.)

Commercial blasting includes the complete removal from steel of all corrosion products, as well as all loose and tight mill scale. *It does not remove the grey oxide binder between scale and steel.* The end result produces a grey steel surface which looks rather streaky. It possesses an anchor pattern for good paint adhesion or bonding.

Sand brush-off blasting includes the complete removal from steel of all corrosion products as well as

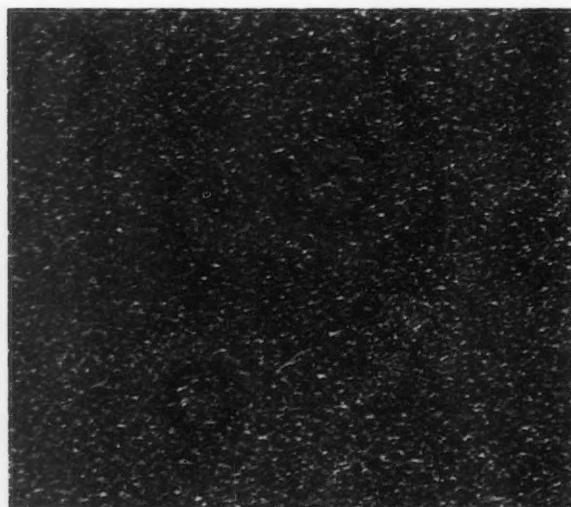


Figure 3—Uniform sand grain will produce a uniform surface anchor. This steel plate was blasted with a hard 30-50 grit sand and it represents either the white or commercial blast finish pattern.

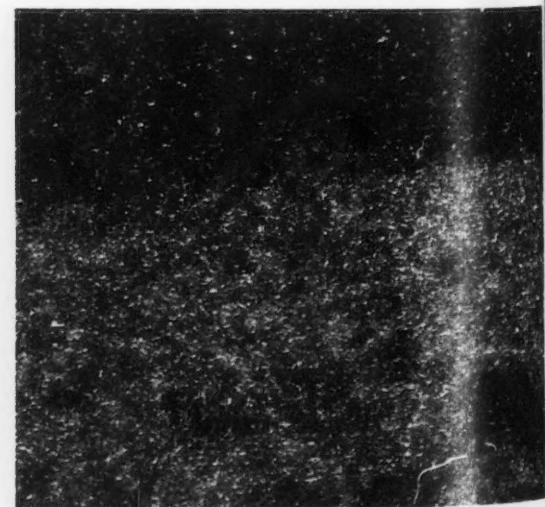


Figure 4—Brush-off sandblasting produced at 650 to 1000 sq. ft. per hour. The light areas are scale free. The dark areas are mill-scaled steel which received a sufficient sand anchor pattern to establish a good overall paint reinforcement during paint application.

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all loose mill scale. The tight mill scale receives an anchor pattern from the speedy passage of sand particles over the general area. Sand brush-off blasting develops an acceptable surface anchor for good paint adhesion and bonding. The steel should be cleaned with a solvent before paint is applied to a brush-off blasted surface. (See Figure 4.)

Advantages

Any one of the three aforesaid systems will produce an anchor pattern for good paint adhesion, bonding, and added paint deposit for a good coating reinforcement. The real differential and advantage lies in the cost to produce the pattern. On the average scale-active steel surface, surface blasting can be done at the following rates:

	Sq. Ft. Produced Per Machine Hour	Approx. Sand Consumption Per Minute	Nozzle Size	Air Pressure
White surface	75—140	30 lbs.	1/8"	90—95 lbs.
Commercial	275—400	30 lbs.	1/8"	90—95 lbs.
Sand Brush-off	650—1,000	30 lbs.	1/8"	90—95 lbs.

Blast Nozzle Wear = 4¢ per hour operation.
Equipment depreciation and maintenance costs must be added.

With a classification of surface conditions, a specific tolerance can be set up; it can be stated in a contract; it can be checked by an inspector, and it can be met by the operator. It should not result in undue losses on the part of the fabricator or the blasting contractor. If the paint manufacturer is satisfied with the surface preparation, he too will gain because his coating was applied to a specific surface condition which he definitely understood, established, and agreed to long before the paint was applied.

The aforesaid costs are for mill scale and corrosion covered steel as generally received from a warehouse or fabricator, and variations govern shapes and locations.

Previously painted metal does not fall under this production classification and must be treated as a separate analysis.

Sand particles or grain sizes that are used for blasting, are important, because the sand will leave an anchor depth on the metal which is proportional to the grain size and air velocity. For a good anchor and optimum paint life, the anchor depth should not exceed one-third of the total thickness of the entire paint assembly.

Let us say that we are interested in a 6 mil paint job, then the total depth of the blast anchor should not exceed 2 mils. A 2 mil pattern can be developed with a good 30 to 50 grit sand. It is equally important to select a sand of larger grit size where a mastic or otherwise extremely heavy coating system must be applied.

Selection of a sand with low breakdown characteristics is important where dust must be kept to a minimum or where the sand is either reused or re-circulated. (See Figure 5.)

Sands are known with as high as 40 percent initial breakdown, yet others will do a fine job with a circulation breakdown of only 7½ percent. It is apparent

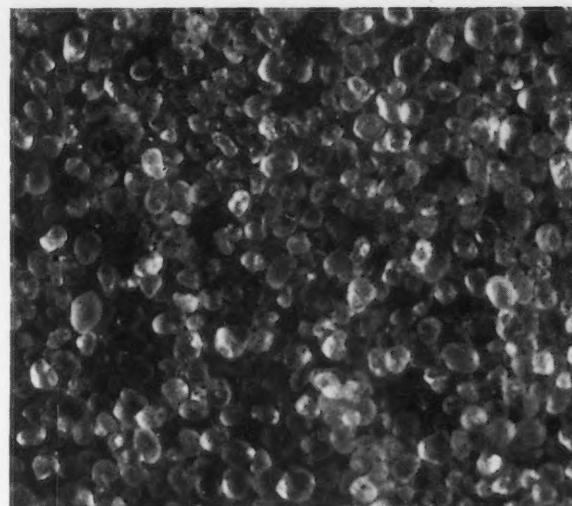


Figure 5—Blasting sand of 30-50 grit size will produce a very uniform surface anchor for good paint bonding and adhesion to steel.

that a sand with a low breakdown rate will also increase total production per each cycle of operation because it is not affected as much by particle disintegration during metal impact. It is needless to say that the operational dust and silicosis hazard is greatly reduced with sand of a low breakdown rate.

Sand dust settles on the blasted surface. If paint is applied directly over a dust active surface, the dust will take from the paint considerable wetting strength which was intended for the steel. The failure of a paint job can be caused by sand dust, especially when paint is applied by gun. The average brush painter can work the dust into a paint film. However, gun painting depends purely on the characteristic of paint and condition of surface to produce a complete wetting and surface adhesion through paint. (See Figure 6.)

Sand that must be recirculated should be properly dried and screened before it is reused. This is true especially with outdoor blasting, where sand may mix with soil and some oversize particles may be circulated into the system. (See Figure 7.)

Oversize particles will produce deeper anchor impressions. Some paints will bridge an oversize anchor. Dust will collect and remain there more readily than on a regular pattern. On atmospheric exposures, these pockets are always susceptible to an early breakdown, and on underwater service they produce local eddies which help to destroy the paint film far ahead of its intended life span. (See Figure 8.)

Sandblasting by the commercial operator generally is limited to plate metal not less than 3/16-inch thickness or in fabricated assemblies of not less than 1/8-inch thickness. Sand under high velocities will produce a surface compression which in turn will cause deformation of a light metal. This does not mean that light metals cannot be blasted. We are not incorporating in this paper sandblasting of very light metals. Special pressures and materials are needed for light work. Time and space does not permit its inclusion.

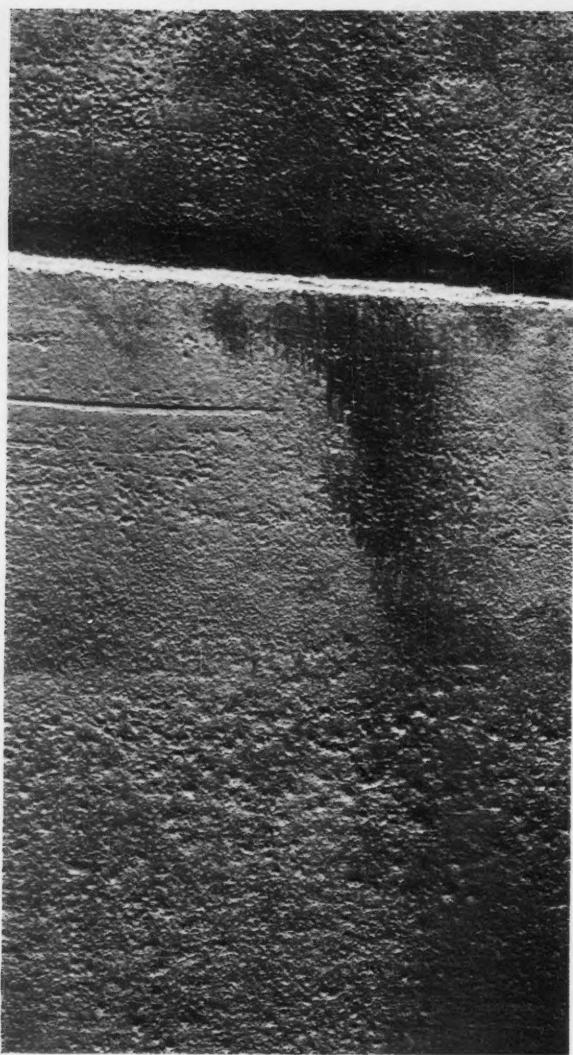


Figure 6—Sand dust on this steel surface absorbed a considerable percentage of the primer's wetting strength. Dark streaks on this photo indicate the only steel surfaces which are sufficiently wetted and covered with primer. Poor paint adherence will result from a dust-active surface.

Present labor costs and competition compels the average fabricator to bargain for low painting costs. Knowledge of surface preparation, coatings, proper equipment, and process selection can mean the difference between success and failure on a job. Proper economizing becomes important as long as the intended end results are not affected.

The reclaiming, drying, screening, and recirculation of blast sand reduces overall production costs, providing that the labor cost to handle this operation is less than 33½ percent of the original sand cost delivered at side. Good sands can be recirculated with new make-up sand as often as ten times before they completely disintegrate.

Semi-automatic sand pick-up and conditioning equipment which will recirculate the sand to the blast tanks, can reduce any sandblasting cost considerably. Sandblasting can thus become more economical and



Figure 7—Blasting sand of excessive size variation will produce an unsatisfactory surface anchor. The coarse particles leave deep impressions on the surface. The finer particles disintegrate more quickly in this manner thus increasing the breakdown rate and the silicosis hazard.

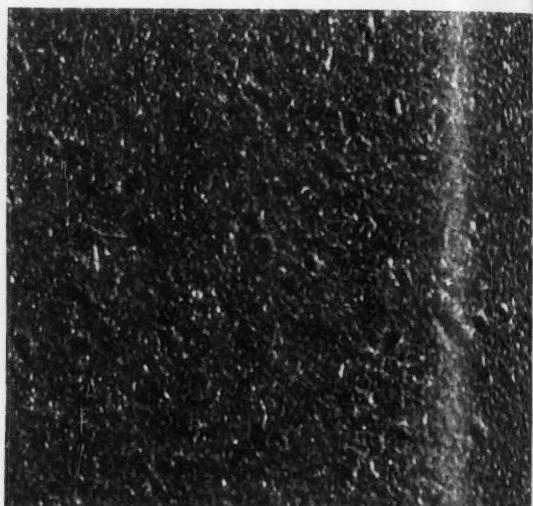


Figure 8—This unsatisfactory surface anchor was produced by a non-uniform sand. Note many pockets which are the result of oversize sand particles. The high points around these pockets cannot hold the necessary paint. The low areas will allow dust and chemical deposits to settle, thus causing earlier paint failure.

acceptable as a surface preparation for general work.

A specific surface condition, whether it is produced by wire brushing, flame cleaning, chemical etching, shot, grit, or sandblasting, cannot be selected blindly. Service requirements and coating characteristics are part of this selection.

The best coating will fail if it is applied to a surface suitable for adhesion; whereas, the coating is basically of a formulation that requires a mechanical bond. It is equally wasteful to apply an adhesive type paint to a white blasted surface, which performs a lifetime of service without vibration, impacts, or such attacks which are otherwise detrimental to a good tight mill scale.

Cooperation between paint producer, equipment

manufacturer, and fabricator is important. It can bring about savings and economies in surface preparation and paint application. It will also extend the useful service life of the steel which is and will be in world-wide use.

Appendix

Legend of Characteristics

Wetting strength covers the maximum distance or penetration the vehicle is capable of delivering the paint or coating assembly in a vertical and horizontal direction on a specific metal.

Wetting time covers the time required for a vehicle to reach the end point of distance and penetration on a metal.

Surface tension is the resultant differential between the normal expansion-contraction coefficient of the metal and that of the coating.

Adhesion covers the molecular attraction of a coating to the metal.

Bonding covers a mechanical anchor requirement to tie a coating to the metal.

Legend of Equipment to Make Tests of the Above Characteristics

Wetting strength of paint can be tested on etched metal or with blotting paper. The area of the test piece must be lined with squares in order to observe and calculate the results obtained with a specific volume of paint.

2. Wetting strength of paint can be tested on etched metal or with blotting paper. The area of the test piece must be lined with squares in order to observe and calculate the results obtained with a specific volume of paint, plus the time required at which a maximum end point of wetting is needed. (Both tests are for the purpose of comparison.)

3. (a) *Mechanically operated.* The cured test specimen and metal assembly is formed over a straight or conical mandrel to determine the radius at which the breakdown of a coating develops.

(b) *Electrically operated.* Tension of the cured film can be measured with elongation apparatus.

4. & 5. Depending on service requirements, adhesion and bonding characteristics are being measured with the knife type scraping tools, with mandrels and with impact equipment.

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The Installation and Economics of Placing Magnesium Anodes at Leaks Repaired on a Pipe Line

By J. A. HOLLOWAY*

Abstract

Magnesium anodes can be easily installed when leaks are repaired and help the anodic areas of the pipe furnish current for the controlling cathodic areas. Leak frequency records indicate that a reduced rate of corrosion can be obtained in this manner until complete cathodic protection can be installed.

TODAY modern methods of pipe line construction eliminate many problems encountered by those who constructed pipe lines two or more decades ago. A large number of the lines constructed during that period were coated with temporary coatings and now are considered bare pipe. Because many of these old lines are still in operation, they must receive special attention to reduce their rate of depreciation.

In this paper the experience is given of the Houston Pipe Line Company in reducing the rate of corrosion at hot-spot areas by placing magnesium anodes at leaks repaired on bare Dresser-coupled lines where complete cathodic protection is either considered uneconomical or contemplated for a later date. Principal factors controlling the rate of corrosion are reviewed and a description given of the manner in which the placing of the anodes at leaks repaired might reduce the rate of corrosion. The

manner of anode installation is described and results obtained are graphically given with a comparison of the number of anodes used, leaks repaired, and leaks prevented.

Corrosion Controlling Factors

The mechanics of corrosion have been described many times in various papers; however, it is felt that a review of some of the principal controlling factors will be of value. It is a well-known fact that each little corroding pit on the pipe is the anode of a battery with other surfaces of the pipe as its cathode. Where many of these pits are located close together, the surface of the pipe receiving the current is located not only among the pits but also on adjacent portions of the line.

Since the rate of corrosion in any pit depends upon the current density within that pit and, from Ohm's Law, it can be seen that the current produced by any pit is controlled by the resistance within the circuit and the voltage between the anode and cathode; and, since the resistance of the circuit cannot be changed easily, it might be said safely that the principal controlling factor is the difference in voltage between the anode and cathode. The voltage of the anode is more or less fixed within its environment and cannot be easily changed, but the cathode

*A paper presented at the South Central Regional Meeting of the National Association of Corrosion Engineers at Dallas, Texas, October 2-4, 1949.

Houston Pipe Line Company, Houston, Texas.

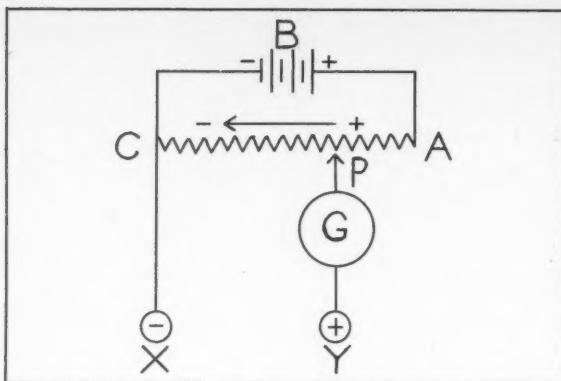


Figure 1

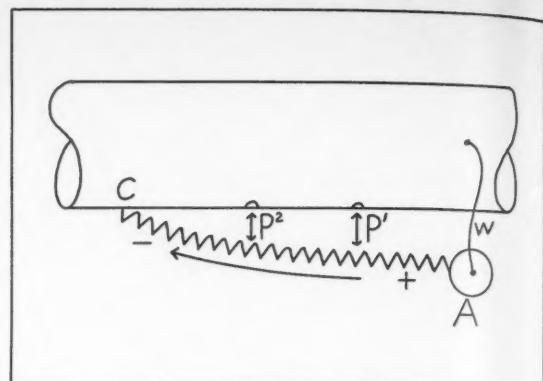


Figure 2

voltage can be changed by polarization or depolarization. While current from the anode constantly polarizes the cathode, other forces are constantly depolarizing it so that the amount of current required from each anode or pit to reach a potential equilibrium with its cathode is also a function of the ratio of the size of the anode to the cathode.

It has been found that in corrosive areas where the line has been replaced with coated pipe, leaving a short section of bare pipe within the anodic area, the rate of corrosion on the pipe left in the anodic area was greatly increased, apparently due to the change in ratio of the anodic to cathodic surfaces. Frequently the pipe was corroded beyond repair within a very short period.

In corrosive areas, where a greater portion of leaks occur, it seems only reasonable that an increase in corrosion rate, due to reduction in size of the anodic surface, will be experienced on the remaining anodic area when that portion of the line uncovered for leak repair is coated, unless current from an outside source is made available to replace current cut off by the coating of the small section of anodic pipe. It also seems reasonable that if more current is made available than was previously furnished by the area coated, a reduction in corrosion rate on the adjacent pipe should be obtained, due to the current from the outside source acting upon the cathode and anode in re-establishing a potential equilibrium between anodic and cathodic surfaces.

The potential equilibrium is obtained when the difference in voltage between the anode and cathode is equal to the IR drop through the soil and other resistances within the circuit. Thus, it seems possible that the IR drop through the soil between an outside current source and the pipe as a cathode might be used to back-out or equalize a part of the voltage between the anodes and cathodes on the pipe. The reduction of voltage between the anode and cathode or driving voltage of the pit would reduce its current or corrosion rate in proportion to the voltage backed out.

The principle is the same as used in the potentiometer to measure a voltage without requiring any current. From the basic circuit of the potentiometer

shown in Figure 1, we can see how a voltage can be backed-out or equalized.

When the voltage of battery B is applied to resistor AC, and is greater than the unknown voltage between X and Y, we can move contact P along resistor AC until the voltage at PC exactly equals the voltage XY as indicated by no current flowing through the galvanometer.

Figure 2 shows how this principle might be applied to a corroding section of bare pipe.

The outside source of current A is connected to the pipe by wire W so that current will flow through the soil resistance AC to cathode C on the pipe. The pits P¹ and P² are anodes on the pipe contacting the soil at P¹ and P². Then, as in the potentiometer circuit, when the IR drop through the soil between P¹ and C, due to current flowing from A through the soil to C, is equal to the potential difference between P¹ and cathode C, no current can flow from pit P¹ due to the backing-out or equalizing of its voltage so that no potential exists between P¹ and the soil at P¹. Likewise when the IR drop through the soil between pit P² and cathode C, due to current flowing from A through the soil to C, is equal to one-half the voltage between P² and cathode C, the driving voltage of P² will be one-half and its current reduced in proportion.

Thus it seems possible that the corrosion rate of anodic areas on bare pipe might be reduced not only by polarization of the cathode but by backing-out a portion of the pit driving voltage or voltage between the anodes and cathodes on the pipe by the IR drop through the soil from an outside current source.

Anode Installation

It has been found that the magnesium anode offers a very convenient method for supplying the current from an outside source when repairing leaks on bare lines. Its installation is very simple and requires very little work and time due to the bellhole excavated for repairing the leak. The lead wire can be easily attached to the pipe by a thermit weld and

a packaged anode placed in the bottom of the hole to be covered when the hole is backfilled; or a bare anode can be used and a shallow hole augered at the bottom of the bellhole for placing the anode in either a dry mix or a slurry.

In order to obtain the greatest reduction in corrosion rate due to the IR drops through the soil between the magnesium anode and cathodes on the pipe, it is apparent that the magnesium anode should be placed near the pipe.

Current measurements made on magnesium anodes installed in the above manner has shown that the output may be expected to vary in relation to the resistivity of the soil and the potential of the pipe. The average life of 17-pound anodes on installations made has been estimated to be between four and five years.

Economics

The principal cost of anode installation was the cost of the materials used, due to the bellhole excavated for repairing the leak. On installations made, it was estimated that the labor required per anode was less than one man hour. The material, when packaged anodes were used, consisted of the packaged anode and the thermit weld material; and, when bare anodes were used, the material was composed of the bare anode with lead wire attached, the backfill and the thermit weld material.

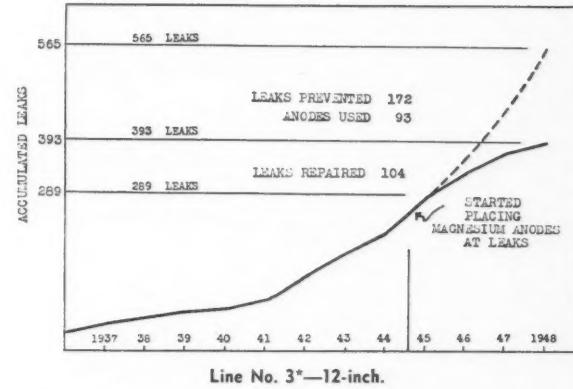
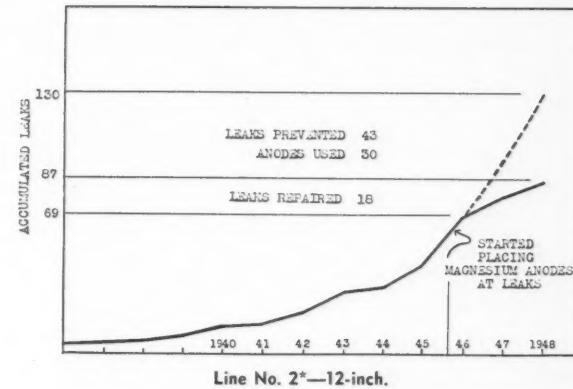
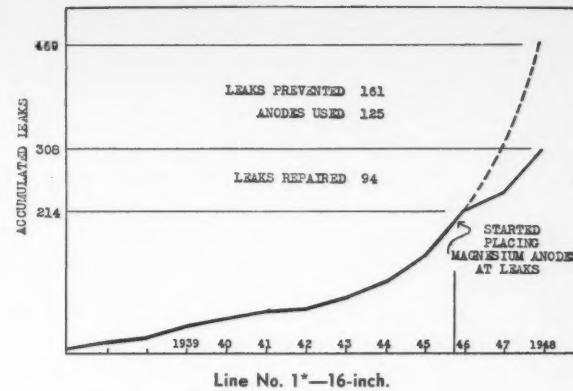
In placing anodes at leaks that portion of the line uncovered for leak repair was left uncleansed and without a coating, so that the total cost of anode installation was more than off-set by the saving in cost of cleaning and coating. However, it is obvious that a greater reduction in corrosion rate should be obtained when the uncovered pipe is coated.

In order to compare the number of anodes used with the number of leaks prevented, accumulated leak frequency curves were plotted on the total anodic areas in each line where magnesium anodes had been placed at leaks. These curves showed a definite reduction in leak frequency on all lines, except two lines on which the practice of placing anodes at leaks had been in operation only a few months.

The curves were extrapolated from the point of leak reduction, which in each case was only a few months after some of the anodes had been placed at leaks. As a basis for extrapolation of the curves, the average percent increase per year in leaks on previous hot-spots common to the line was taken.

Line No. 1 is a 16-inch bare Dresser-coupled line with 29 anodic areas totaling 26,000 feet. Magnesium anodes have been placed at leaks for $2\frac{1}{2}$ years with a total of 125 used. Ninety-four leaks have been repaired since the break in the curve with the extended curve indicating that 161 leaks have been prevented, or 63 percent leak reduction.

Line No. 2 is another 16-inch bare Dresser-coupled line with nine corrosive areas totaling 9000 feet. Anodes have been placed at leaks for $2\frac{1}{2}$ years with a total of 30 anodes used. Eighteen leaks have been repaired and 43 leaks have been prevented, or 70 percent leak reduction.

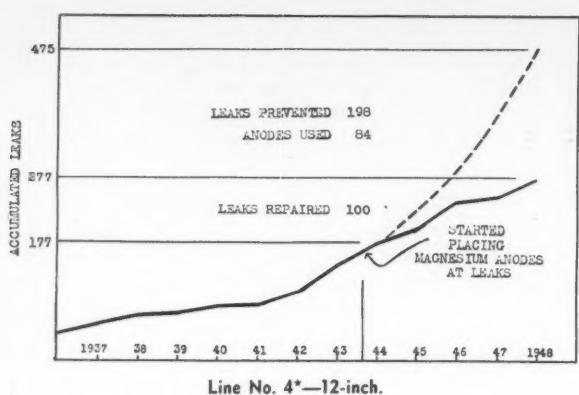


Line No. 3 is a 12-inch bare Dresser-coupled line with 28 corrosive areas totaling 23,400 feet. Anodes have been placed at leaks for $3\frac{1}{2}$ years with a total of 93 anodes used. One hundred and four leaks have been repaired and an estimated 172 leaks prevented, or 62 percent leak reduction.

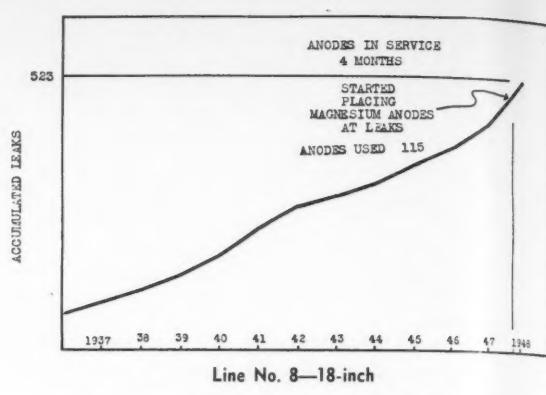
Line No. 4 is another 12-inch bare Dresser-coupled line with 29 corrosive areas totaling 29,400 feet. Anodes have been placed at leaks for $4\frac{1}{2}$ years with a total of 84 anodes used. One hundred leaks have been repaired and an estimated 198 leaks prevented, or 66 percent leak reduction.

Line No. 5 is a bare 18-inch Dresser-coupled line with 30 corrosive areas totaling 16,200 feet. Anodes

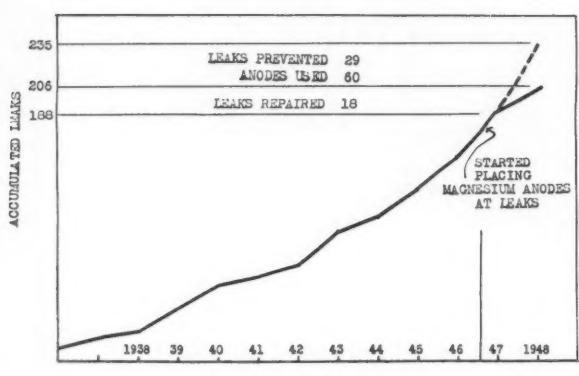
*Accumulated leak curve on corrosive areas bare Dresser-coupled line.



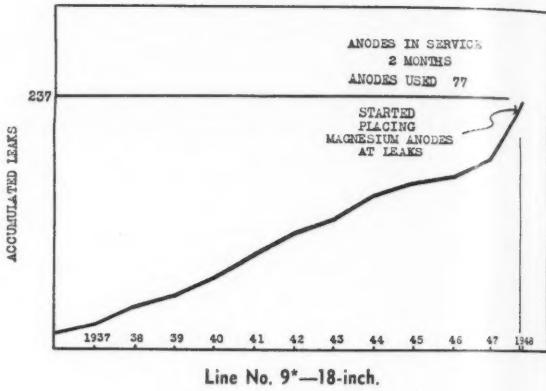
Line No. 4*—12-inch.



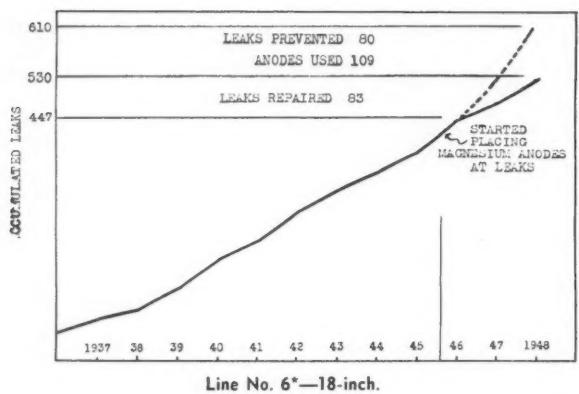
Line No. 8—18-inch



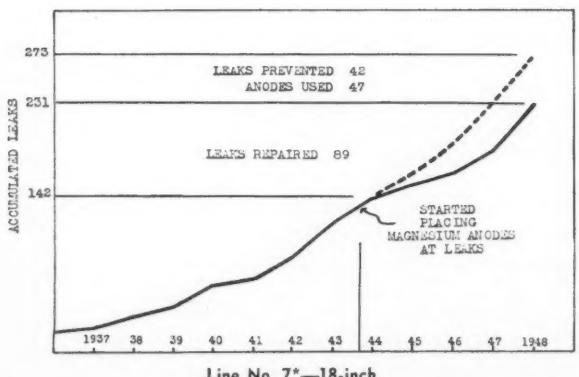
Line No. 5*—18-inch.



Line No. 9*—18-inch.



Line No. 6*—18-inch.



Line No. 7*—18-inch.

have been placed at leaks for 1½ years with a total of 60 anodes used. Eighteen leaks have been repaired and 29 leaks prevented, or 29 percent leak reduction.

Line No. 6 is another 18-inch bare Dresser-coupled line with 29 corrosive areas totaling 28,000 feet. Anodes have been placed at leaks for 2½ years with a total of 109 anodes used. Eighty-three leaks have been repaired and an estimated 80 leaks prevented, or 49 percent leak reduction.

Line No. 7 is another 18-inch bare Dresser-coupled line with 24 corrosive areas totaling 20,700 feet. Anodes have been placed at leaks for 4½ years with a total of 47 anodes used. Eighty-nine leaks have been repaired with an estimated 42 leaks prevented, or 32 percent leak reduction.

Line No. 8 is a bare 18-inch Dresser-coupled line with 48 corrosive areas totaling 49,700 feet. The curve does not indicate a reduction in leak frequency as anodes have been placed at leaks only about four months. One hundred fifteen anodes have been used.

Line No. 9 is another bare 18-inch Dresser-coupled line with 18 corrosive areas totaling 13,000 feet. Seventy-seven anodes have been placed at leaks within the last two months with no leak reduction indicated due to the short period in which the anodes have been operating.

Accumulated leak frequency curves on corrosive areas, as has been shown, indicate a substantial reduction in leak frequency was obtained as a result of the magnesium anodes placed at leaks. On the seven lines where leak reduction was indicated a total

*Accumulated leak curve on corrosive areas bare Dresser-coupled line.

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of 548 anodes were used. Five hundred and six leaks were repaired with the extended curves indicating that 725 leaks were prevented with an estimated one-half of the life of the anodes used. Over all corrosive areas on the seven lines described an average of one anode every 275 feet had been installed with a calculated current density of approximately .17 milliamperes per square foot and an estimated leak reduction of 59 percent.

While it is apparent that the placing of magnesium anodes at leaks will give a reduced rate of corrosion, this method of anode installation should not be expected to give complete cathodic protection to a corrosive area. However, it should be kept in mind that where leaks occur corrosion is active and a reduced rate might be desirable.

Summary of Discussion

Corrosion and Protection of Offshore Drilling Rigs*

By F. L. LaQUE*

ON THE occasion of the National Association of Corrosion Engineers' Annual Conference in Cincinnati in April, 1949, the Salt Water Corrosion Symposium provided an opportunity for the discussion of the problems of corrosion and protection of steel piling with particular reference to structures of offshore drilling rigs.

The principal discussion stemmed from the paper by H. A. Humble entitled "Cathodic Protection of Steel Piling in Sea Water" which was published subsequently in the September, 1949, issue of CORROSION, Vol. 5, No. 9, p. 292. That publication included also a discussion by G. C. Cox with particular reference to effects of cathodic coatings, and by C. P. Larrabee and the present author of some of the details of Humble's observations of the distribution of corrosion of steel partially immersed in sea water and of the powerful local cells set up between the continuously immersed and intermittently immersed surfaces in the tidal zone. It may be noted that in further discussion of this paper Jack Battle of the Humble Oil & Refining Company stated that observations during the dismantling of a temporary drilling rig structure in the Gulf of Mexico tended to support Humble's findings re the distribution of corrosion. Reference should be made also to another paper in this session by C. W. Ross entitled "Deterioration of Steel Sheet Pile Groins at Palm Beach, Florida" and published in the October, 1949, issue of CORROSION, Vol. 5, No. 10, p. 339. Those interested in the details of these studies should review the papers mentioned. But, for convenient reference and as an introduction to this summary of discussion by others who par-

ticipated in the session, the following principal points are listed:

1. Maximum corrosion of bare steel occurs in the splash zone just above the usual high tide level.
2. Minimum corrosion occurs in the tidal zone which receives local cell cathodic protection by current which flows from an anodic area just below low tide.
3. A secondary peak in corrosion rate occurs in the anodic region just below low tide.
4. Corrosion below the mud line ordinarily proceeds at rates lower than those in the water or the atmosphere above it.
5. It is easy to arrest corrosion below low tide by the application of cathodic protection.
6. It is relatively difficult, and perhaps uneconomical, to arrest corrosion in the tidal zone and especially in the most critical area just above high tide by the application of cathodic protection.
7. Steel in the tidal zone and just above it should be protected by a protective coating or a sheathing of corrosion resisting metal as a supplement to cathodic protection of the continuously immersed areas.
8. Experiments with Monel in the tidal zone connected to steel below low tide as compared to steel in both zones showed that:
 - a. Corrosion of steel below low tide in contact with Monel in the tidal zone was no faster than when in contact with steel in the tidal zone.
 - b. It was easier rather than more difficult to cathodically protect steel below low tide when in contact with Monel instead of steel in the tidal zone. (Presumably this was due to the greater ease of polarizing Monel and would apply as well to any other corrosion resisting metal having favorable cathodic polarization characteristics.)

*Summarized discussions given during panel on Corrosion and Protection of Offshore Drilling Rigs, Fifth Annual Conference, National Association of Corrosion Engineers, Cincinnati, Ohio, April 11-14, 1949.

In charge of Corrosion Engineering Section, Development & Research Division, The International Nickel Co., Inc., New York, N. Y.

The several points that were developed in the general discussion can be classified under general headings, such as factors in the corrosion of steel, effects of marine organisms, protective coatings, metallic sheathing and cathodic protection. They will be summarized here under these headings.

Corrosion of Steel

In replying to some questions by Hugh P. Godard of the Aluminum Laboratories, Ltd., the present author stated:

Effect of Temperature

The effects of temperature on the corrosion of steel are complicated by the action of attached fouling organisms which are also influenced by temperature effects. In tests in flowing sea water where no fouling organisms became attached to small completely immersed specimens, corrosion of steel in sea water at 52° F proceeded at a rate of 0.007-inch per year as compared with 0.014-inch per year in water at 70° F.

Tests of steel at different points around the world, such as those carried out by the British Institution of Civil Engineers,¹ have shown a remarkably small influence of latitude and sea water temperature on the rates of corrosion of continuously immersed steel specimens. Apparently in the warmer waters the accumulations of heavy growths of marine organisms which stifle corrosion compensate for the accelerating effect of temperature, while in the cooler waters the absence of protective organisms is made up for by the lesser corrosive effect of the cold water.

Effects of Brackish Water

Because brackish waters are frequently associated with industrial or sewage contamination of varying sorts, it is impractical to make any precise statements about rates of corrosion to be expected in brackish waters as a class as compared with clean sea water of full salinity. Here again, however, compensating factors, such as the lower dissolved oxygen content of highly polluted waters, play a part so that tests in a number of brackish harbors have shown that the rates of corrosion of continuously immersed steel are of the same order of magnitude as in clean sea water.

Proper Depth of Immersion of Test Pieces

In answer to a question as to the proper depth of immersion of corrosion test specimens, the present author suggested a depth of two to three feet below extreme low tide as being practical. He also pointed out that, as demonstrated by the data in Humble's paper and its discussion, the corrosion of partially immersed specimens can be studied properly only by the use of specimens large enough to extend from well below low tide to well above high tide or by a series of electrically bonded specimens disposed through the same region. Exposure of isolated and insulated specimens extending through the same region—such as has been done so much in the past—will yield unreliable results.

Effect of Oil Films

In answer to a question from Cecil Phillips of the Humble Oil & Refining Company, Baytown, Texas, the present author stated that oil films on the surface of the water can be expected to provide considerable protection in the tidal zone. He mentioned many observations of such effects in New York Harbor and cited some tests at Quincy, Massachusetts, where test specimens exposed in the tidal zone had suffered practically no corrosion as a result of protection received from oily coatings deposited with the rise and fall of the tides.

Effects of Chlorine

In answer to a question raised by W. B. Brooks of The Dow Chemical Company, Freeport, Texas, as to effects of chlorine additions on the corrosion of steel by sea water, he was referred to the paper by V. B. Volkening² and its discussion presented at this conference. Under the conditions of exposure to sea water likely to be associated with piling, it is the present author's opinion that an addition of chlorine sufficient to prevent the growth of fouling organisms would not of itself be expected to have any significant effect on the durability of steel piling.

Effects of Marine Organisms

Protective effects of marine organisms on the corrosion of steel in warm sea water have already been mentioned under the heading "Corrosion of Steel."

In answer to a question raised from the floor, Dr. Wm. F. Clapp of Duxbury, Massachusetts, stated that bitumen impregnated fabrics or felts could be expected to act as effective barriers to the penetration of teredos, barnacles and other marine organisms—provided they were continuous and did not have structural defects. In this connection, R. A. Brannon of the Humble Pipe Line Company, Houston, Texas, reported his experiences to the effect that, in the process of their growth, barnacles will distort and eventually displace or dislodge any plastic material which is subject to deformation under pressure. However, Mr. Brannon stated that his casual observations should not be taken as tending to upset the general situation as described by that eminent authority—Dr. Clapp.

In answer to another general question, the present author offered the opinion that the presence of marine organisms would not offer any handicap to the application of cathodic protection and might even favor such protection in the tidal zone by helping retain a greater volume of electrolyte with greater continuity of cathodic protection as the tide fell.

Protective Coatings

The use of protective coatings to take care of local action between the tidal and submerged zones was discussed in some detail in Mr. Humble's paper, given on

In his discussion of the general problem, Mr. Jackson and similar Battle of the Humble Oil & Refining Company offered three different the following remarks which are quoted verbatim on this topic:

"The program of the Humble Oil & Refining Company for the corrosion protection of our off-shore containing

drilling platforms has been dictated primarily on an economic basis. Federal regulations require that when an off-shore location is abandoned, the entire structure be removed below the mud line. Consequently, our program has been based upon the premise that we should wait until we could determine if commercial production would be obtained from the off-shore structure, that is, whether the structure is to be a permanent one, before we provide relatively complete corrosion protection.

"At the present time we have, off the coast of Grand Isle, Louisiana, one large structure from which we expect to drill some eight or nine wells and some seven or eight smaller structures from which one or more wells will be drilled. At this time production in commercial quantity has been obtained from the large structure and only recently did we install any type of cathodic protection.

"Prior to the erection of these structures, we had very limited information on which to base our corrosion protection program. We were somewhat fortunate in that the dismantling of a temporary structure which had been in use for approximately one year for the purpose of obtaining test cores gave us an opportunity to examine this thoroughly for corrosion. In general, our observations on this structure tended to support the findings of Mr. H. A. Humble of the Dow Chemical Company in that the more serious corrosive attack would occur in the tidal zone and in the salt-spray area above.

"On the basis of this information, the 16-inch steel casing which was used to fabricate the templates of the structure were wrapped with alternate layers of coal-tar asphalt and fibre glass wrap with a final wrapping of Kraft paper in the interval from -10 to +15 with reference to the mean tide level. The piling below this level was bare and that above the fibre glass wrap has been protected by conventional paints or by a non-hardening, grease-type paint."

In connection with the proper choice of protective coatings, W. J. Clayton of the Minnesota Mining & Mfg. Company, Detroit, Michigan, submitted the following resume of his remarks during the discussion: "In the course of the last ten years a number of new synthetic polymers have been developed and produced on a commercial basis which have made possible the development of protective coatings with remarkably fine resistance to conditions of severe corrosion. Neither the manufacturers of these new products, nor their customers, are able to reach complete agreement with respect to the relative merits of the different brands of these new materials. I shall, therefore, confine my remarks on this occasion to conclusions which appear to be generally accepted by most engineers concerned with the development and use of protective coatings.

"Practically all of the coating systems which have given outstanding service on off-shore drilling rigs and similar installations are composed of at least three different types of materials. The primer used in this type of coating system must have excellent adhesion not only to clean metal, but also to surfaces contaminated with small amounts of moisture and

other impurities. The adhesion of this primer, both to the metal surface and to the coatings used over it, must not be deteriorated by severe conditions of exposure. The so-called wash primer which was originally developed by the Carbide and Carbon Company under a Navy contract and which is now produced by a large number of coating manufacturers, is probably one of the best primers available for use on marine installations.

"The second material used in this type of coating system is an anti-corrosive coating which contains ingredients which retard corrosion creep at breaks in the coating. This second component of the coating system is usually not sufficiently resistant to mechanical abuse to be used alone. Hence a tough finish coat is required over the anti-corrosive material. This last material should have outstanding resistance to abrasion, mechanical and thermal shock and to the corrosive conditions to which the system is to be subjected. Failure to pick a completely adequate finish coating material is one of the most likely errors that a corrosion engineer may make in selecting a coating system for off-shore rigs.

"Experience with protective coatings on the structures of offshore drilling rigs is, of course limited, but an impressive number of successful service tests have been made with coating systems of the type described above on steel surfaces subjected to exposure conditions similar to those encountered on drilling rigs. Coating systems of this type have withstood four years of constant usage, both below the water line and above the water line on ocean going ships without exhibiting any signs of failure. Numerous test applications of these coatings on steel locks which are subject to exposure to salt water and river water are still in excellent condition after two years. A number of tow-boats, barges and other small craft have been treated with these new coating systems. Recent inspections of these vessels have shown that the performance of the coatings has been excellent.

"All available technical information regarding the properties and performance of coatings of this type and the results of large scale tests indicate that the best coatings on the market today will give outstanding service in the protection of off-shore drilling rigs."

Metallic Sheathing

The present author contributed a discussion of the proposed use of Monel as a sheathing for the critical region extending from just below low tide to through the splash zone just above high tide. He illustrated the use of such sheathing in conjunction with other methods of protection by the schematic diagram reproduced here. In this diagram it is indicated that the steel below low tide could be protected by cathodic current without any supplementary coating and that such coatings could, of course, be used to advantage along with cathodic protection.

One of the principal advantages of a corrosion resisting metal sheathing is that it can be applied in the field after there has been some accumulation of

organisms and corrosion products on the surfaces to be protected. The presence of organisms and loose rust, etc., makes it very difficult, if not impossible, to achieve a satisfactory preparation of the steel to receive or renew conventional protective coatings within the limited time available between tides—and especially where there is considerable wave action.

The data included in Humble's paper support the belief that Monel will be adequately durable and will not interfere with cathodic protection of the immersed portions of the piling while receiving the benefit of such protection during the time of its immersion. Such cathodic protection will also eliminate galvanic effects at the junction between Monel and steel underwater. Protective coatings will take care of any such effects at the junction between the dissimilar metals in the atmosphere and, for greatest safety, a protective coating should be applied to the Monel as well as to the steel—at least for a distance of three or four inches from the joint.

Monel sheathing can be applied either by welding using metallic arc or shielded arc methods or by the use of gasketed mechanical joints under circumstances where welding would introduce a fire hazard—as around loading docks. Where the location of the critical zones requiring metallic protection can be established satisfactorily in advance, the sheathing can be applied before the piles are driven and, in such instances, also, the protective metal can be in the form of integrally bonded cladding rather than sheet metal sheathing.

Where unbonded sheathing is used, the sealed off space between the sheathing and the piling metal can be filled with a suitable liquid, such as a heavy oil or pitch, or even sea water made more alkaline by the addition of caustic soda.

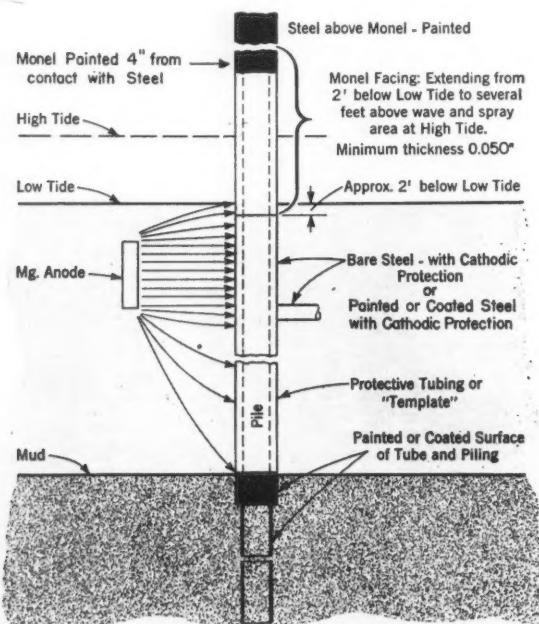


Figure 1—Proposed disposition of Monel in general scheme of protection of offshore drilling structure supports.

Cathodic Protection Practice

As might be expected, there was considerable discussion of cathodic protection of drilling rig structures and piling. The practice of the Humble Oil & Refining Company with respect to a particular structure in the Gulf of Mexico was described by Jack Battle of that company as a supplement to his remarks re protective coatings, etc., already quoted under that heading in this summary. His description of their application of cathodic protection is quoted here:

"The 16-inch steel casing which was used to fabricate the templates of the structure were wrapped with alternate layers of coal-tar asphalt and fibre glass wrap with a final wrapping of Kraft paper in the interval from -10 to +15 with reference to the mean tide level. The piling below this level was bare and that above the fibre glass wrap has been protected by conventional paints or by a non-hardening grease-type paint.

"On completion of the first well from this structure, the potential of the structure with reference to a remote copper sulfate electrode was observed to be -0.65 volts and a very simple experimental cathodic protection installation was made using magnesium anodes. Some three months after initiation of cathodic protection, the potential of the structure with respect to a remote copper sulfate electrode was found to have been raised to -0.85 volts. It should be emphasized that the present installation is an experimental one and the installation in such units on any of the smaller structures will more than likely be modified on the basis of the information gained from our present installation on the large structure. At the present time the installation has been in service too short a time to provide any conclusive evidence of its effectiveness; however, the increased potential is believed indicative that appreciable protection is being obtained."

Mr. Gordon L. Doremus of Cathodic Protection Service, Houston, Texas, contributed a description of the scheme of cathodic protection applied to two offshore drilling platforms as follows:

"At the present time our company has designed and installed cathodic protection systems on two offshore drilling platforms in the Gulf Coast area. Magnesium anodes were selected as source of protective current in both instances for reasons of economy, simplicity of installation, and freedom from maintenance.

"The first structure protected was located below Cameron, Louisiana, in approximately 33 feet of water. The platform was supported on thirty-six 30-inch O.D. cylindrical steel piles, cross braced with 1½-inch stranded galvanized bridge cable. All piles were coated with coal tar enamel and were driven 72 feet below the mud line. The galvanized cable was considered to be particularly vulnerable to underwater corrosion.

"Current requirements for cathodic protection of the piles, cables, and well conductor pipe were calculated on the basis of three milliamperes per square foot of effective bare surface below mean high tide.

assuming that the coal tar coating was 60 percent intact and that current requirements could be reduced to this low level by polarization of the structure at high current densities for a short period of time. This high current density technique, which is patented³ but available for licensing, has been shown to deposit a calcareous coating on the surfaces to be protected, which makes possible establishment of immediate protection by application of current densities of three milliamperes per square foot or less.⁴ Definite ampere-hour economy results from use of this process.

"The necessary high current density was supplied by 1700 feet of magnesium Galvo-line distributed about the structure in 30-foot lengths. This material was consumed within two weeks. The main installation, consisting of twenty-eight 51-pound magnesium anodes suspended in pairs from the platform by means of insulated cables, was allowed to operate at maximum output during this initial polarization period. These anodes were subsequently adjusted to a total output of 42 amperes, or 1½ amperes per anode, thus projecting a life slightly greater than two years for the installation. A survey of piling potentials, using a specially constructed saturated calomel electrode, gave values ranging from -0.96_v to -1.00_v , which lie well above the minimum protective level of -0.78_v .²

"The second platform protected was of the jacket-template type, also located off the Louisiana coast. This structure had received no protective coating whatsoever, and current requirements were calculated to be 78 amperes for the 26,000 square feet of surface below mean high tide. Calcareous coating was deposited by a total of 2600 feet of Galvo-line distributed above the structure in 22-foot lengths, the water depth being considerably less at this location. It was found possible to maintain potentials in excess of -0.92_v by adjusting the main installation, after consumption of the Galvo-line, to an output corresponding to 1.5 amperes per anode, again projecting a life in excess of two years for the protective system.

"A close check will be kept on the performance of these installations, which serve as interesting examples of the successful application of test data being obtained at Kure Beach Corrosion Testing Station to a very important practical problem."

Current Density Requirements

In addition to the details of current densities being used in practice as described already, there was considerable discussion of this phase of the subject at the session.

Oliver Osborn of The Dow Chemical Company, Freeport, Texas, provided the following information regarding the effect of time and current density on the current required to maintain protection of steel in sea water:

"In the latter part of 1945 magnesium anodes were connected to the side walls of the 4-year-old sea water flume at our Freeport, Texas, plants. Anodes were spaced at 32-foot intervals, and protection was obtained with an initial current density of approximately 10 milliamperes/sq. ft. Through subsequent

years the current required to maintain protection was observed; and it was found that there was a steady decrease of current requirements, with an apparent equilibrium value of slightly over one ma/sq. ft. being reached after about four years. Water velocity was 3-5 feet/sec.

"This data apparently demonstrates that very low current requirement values will be obtained with time, even though the initial values were never in excess of 10 ma/sq. ft."

George C. Cox provided considerable data with appropriate comments with particular reference to the range of current density in which the most protective calcareous deposits would be formed on the steel undergoing cathodic protection. His extended remarks are quoted verbatim and the graphs referred to are included here:

"Supplemental to my remarks at the Symposium in regard to the protection of steel in tidal areas by impressed currents, it is interesting to plot as a function of current density the magnesium hydroxide and calcium carbonate equivalents of the values given in Table IV of Humble's paper in CORROSION, Vol. 4, July, 1948. The attached graph shows a plot of these values.

"Based on the theory of cement mixtures, it would be expected that coatings of minimum porosity would be produced when sea or seaport waters are electrolyzed at effective cathodic current densities at or near the point of intersection of the two curves. Similarly, economically useful protective coatings should be produced from about one-third to three times the indicated effective current density at this point of intersection. Outside of these ranges considerably less efficient protective coating mixtures should be produced.

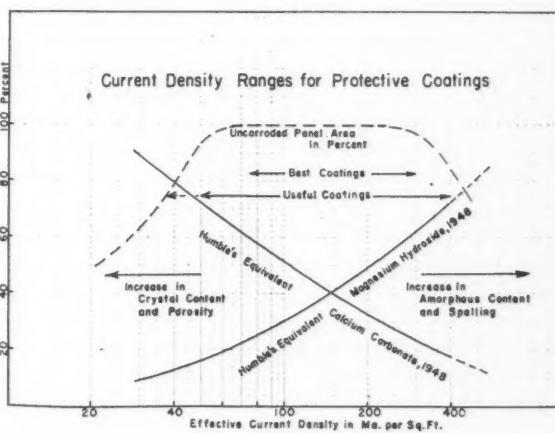


Figure 2

"The above conditions are substantially the same as was found by me in some earlier work, a typical curve of which is superimposed as a dotted line on the graph. Curves of this type were obtained by estimating the uncorroded area of a series of electro-coated panels after breakdown treatments of equal time periods in an alternate immersion testing machine when using sea water as the corroding liquid. Except that the panels were lowered and raised in and out of the solution, the machine was similar to

that used by Messrs. Walton and Eldredge (Proc. ASTM, Vol. 44, 1944). The electrocoated panels for a breakdown test were formed with the same ampere-hour expenditure but at different current densities.

"The correlation of these graphs indicates how maximum density coatings can be formed on both the tidal areas and total submerged areas of steel piling in sea water. Depending upon local conditions, the coating-forming operation can be accomplished by the use of an external current source connected to suitably located anodes or through the use of properly placed sacrificial magnesium rod or ribbon anodes, such as "Galvo-Line."

"Although the potential difference generated by a magnesium-iron galvanic couple in sea water is sufficient to cause the electro-deposition of valuable protective coatings as discussed above, the potential difference of a zinc-iron galvanic couple is insufficient to do so. Therefore, care should be taken to avoid misinterpreting the usefulness of any cathodic deposits formed by zinc anodes which are coupled to steel. On large steel structures such deposits have been found entirely too spotty and porous to be of any value as a protective coating, and serious deep pitting has been observed. This is especially true in the wind-water area where corrosion will continue to be almost as destructive as if no zinc anodes were used.

"If desired, correctly formed electrocoatings can be maintained by the use of either magnesium or zinc anodes. When properly maintained, these coatings can be made to give any desired number of years of increased life to a steel marine structure at a cost equal to or less than other methods. As a result, these coatings, when properly applied and maintained, put steel piling on a sound competitive basis with other piling materials.

"An unbiased examination of the published papers, as well as the official reports to the Army and Navy on this subject show that various investigators substantiate these findings with regard to effective limits of current density for electroplating valuable protective coatings on steel structures."

With reference to the phase of the subject covered by G. C. Cox's remarks just quoted, O. J. Streever of the Newport News Shipbuilding and Dry Dock Company submitted a further discussion as follows:

"During the discussion of the 'Corrosion and Protection of Offshore Drilling Rigs,' Col. Geo. C. Cox made reference to a report submitted by the Newport News Shipbuilding and Dry Dock Company to the U. S. Army Transportation Corps Board, covering a series of tests made at Newport News, Va., on a Research and Development Contract, dwelling particularly on tests made in ships tanks. From Col. Cox's remarks, it appeared the report had stated that satisfactory electrolytic protective coatings could be deposited only at current-densities between 100 and 300 ma per square foot. However, as the report referred to covered a series of tests in which the current-density and time periods were specified in the contract and because these tests were conducted and the reports prepared under my direction, it appeared advisable to further elaborate on the nature of the experiments.

"Feeling that, in his discussion, Col. Cox was too brief and did not adequately bring out the conditions which were dominant in planning the tests, I attempted to explain that the current-time ratio of the tests conducted were predicated on the assumption that the ship operator could not afford the time required to process the tanks at a low current rate. Therefore, the current-rates were set and varied to obtain a coating in as short a time as practicable but not exceeding the maximum allowed time. It was explained that even though no completely satisfactory coating was obtained in any test, the results of these particular tests indicated that a current-density of 175 ma would, under certain conditions produce the best coating.

"The tanks were filled with the normal harbor water which was natural sea water diluted by fresh James River water to a salinity of about 50 percent that of sea water. The temperature averaged about 65° F.

"With these test conditions the indications were that clean areas of the tank subjected to a current-density of 175 ma would obtain a very satisfactory protective coating in about 100 hours.

"The writer does not believe that there is a definite current-density which can be set as either minimum or maximum for forming an electrolytic protective coating. Any such current-density would have to be qualified by an analysis of the conjugate conditions and the use for which the coating is intended.

"Prompted by a question from the floor relative to the use of a low current-density for a long time and more closely associated with the discuss of the paper on drill rigs, the writer gave a partial description of a test then in progress at Newport News in an attempt to clean and coat the surfaces of a heavily rusted steel tank which had been used to transport sludge-oil. A magnesium sacrificial anode was used to generate the current which was limited to eleven milliamperes per square foot of tank surface at the start, dropping off to four milliamperes in two months of continuous action. At the end of two months a major part of the surface had been cleaned and coated. This coating was then maintained at a density of one millampere per square foot of tank surface for several months. The results of this particular test would indicate the probable use of low current density applications for cleaning and inhibiting the further corrosion of submerged structures."

In conclusion, it is evident that much attention is being given the scientific foundation and the technical details of the several means of protecting steel piling as used for off-shore drilling structures, loading docks, bulkheads and the like. It can be expected that satisfactory and economical methods will become established in the immediate future and that these methods will permit choices to suit particular circumstances as they arise.

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2. V. B. Volkening, "The Corrosion of Steel by Chlorinated Sea Water at Various Velocities," *Corrosion*, 6, No. 4, 123-128 (1950) Apr.
3. G. C. Cox, U. S. Patents No. 2,200,469 (1940) and 2,417,064 (1947).
4. H. A. Humble, "Cathodic Protection of Steel in Sea Water with Magnesium Anodes," *Corrosion*, 4, 3-15 (1948).



Discussions

Discussion on "THE CORROSION RESISTANCE OF SPRAYED METAL COATINGS," by Walter B. Meyer. *CORROSION*, 5, No. 9, 282-7 (1949) Sept.

By W. E. Ballard, Metallisation Limited, Barclays Bank Chambers, Dudley, Worcs., England.

We would like to point out that British industry began experimenting with metal spraying in 1922 instead of 1932. The author's company commenced the development of metal spraying in 1922 and has continuously maintained a laboratory to work on corrosion and metal spraying problems from all angles. It is very definitely certain that there is more metallising carried out for anti-corrosive purposes in this country, either per head of population or in proportion to capital expended, than in any other country in the world, and that this has been largely brought about by a careful adherence to scientific facts and a very careful modification of propaganda to deal only with facts that are well-known. It is as a result of this continuous work that the process is now so well-known and so greatly used in this country. It is rather important to note that the trend in England is not to use high speed deposition where the maximum protection is needed.

The Abbey Works steel job cited in the paper is the largest metal spraying contract job undertaken to date. Some fifteen thousand tons (4½ million sq. ft.) are involved. To cope with large contract jobs a mechanized plant has been designed and is in use. The structural steel is first passed through a specially built cleaning and blasting machine and then is passed immediately to an automatic spraying machine. The cost of preparing finished metallized steel has been greatly reduced by this process.

We wish to point out that although metallizing of the Howrah Bridge was contemplated before the war it was painted and none of it was metallized.

Metallizing of large structures is an expensive operation at best and the choice of coatings must be governed by careful laboratory tests. Power conduits for hydro-electric plants in the Scotch Highlands and railway coaches for use in the East are large metallizing jobs currently being carried out. The growth of the process has been very rapid and is accelerating.

By E. Bateson, Rendel, Palmer & Tritton, 125 Victoria Street, Westminster, London, S.W.1.

The Howrah Bridge over the Hoogley River at Calcutta, India, is not being metallized as stated in Mr. Meyer's paper.

The facts are that shortly before the war my firm carried out extensive tests of the protective value of sprayed-zinc coatings applied to steel by various methods, and on the basis of these tests, prepared a specification and scheme for metallising the superstructure of the New Howrah Bridge over the River Hoogley at Calcutta. As the superstructure contained approximately 25,000 tons of very heavy structural steelwork—some of the members weighed up to 60 tons—the scheme was a very ambitious one, and had it gone forward much valuable information would have been obtained in regard to carrying out the work as well as the protective value of metallisation.

Unfortunately, owing to the advent of World War No. 2, and the resultant complete concentration of the resources of the United Kingdom on war requirements, the necessary equipment for the surface preparation and metallisation of the steelwork was no longer obtainable, and the scheme had to be abandoned.

The protection scheme actually adopted consisted of cleaning the steel as efficiently as possible by chipping, wire brushing, etc., and it was then given, in the fabrication shop, a good priming coat of red lead paint. As the erection proceeded, damage to the priming coat was made good and a brushed undercoat of aluminium paint was then applied, followed by a final sprayed coat of aluminium paint. The undercoat was slightly tinted to differentiate from the final coat which was sprayed, as brush application was found to pick up the undercoat.

The bridge was completed in all essentials and was opened for traffic in February, 1943. Since then the only work carried out has been concerned with the replacement of the war-time emergency lighting system by a complete system, and general maintenance work.

In June, 1948, the Bridge Engineer reported that:

"... the general condition of the paint work is good. The original paint has lost its lustre but much of this effect is due to the deposition of soot and foreign matter, removal of which restores the appearance to a large extent."

Incidentally, as a further point of interest, it should be noted that the low-alloy steel used for the superstructure was of the copper-bearing type containing not less than 0.3% of copper, so that the steel can be expected to have a better corrosion-resistance value than ordinary mild steel.

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Topic of the Month

Extra Low Carbon Stainless Steel

By ARBA THOMAS*

OF THE VARIOUS types of stainless steels, the austenitic or chromium-nickel grades are in general the most resistant to corrosion. These steels have found wide and satisfactory application in various chemical and processing industries. However, they have always been characterized by one draw-back which is their susceptibility to localized corrosive attack in the parent metal immediately adjacent to the welds. In many applications, grades such as Type 304 (carbon 0.8% max.) are quite satisfactory as welded but in the more severe corrosive environments this grade is liable to fail because of intergranular corrosion adjacent to the welded areas. Where practical, welded equipment is annealed above 1900° F in order to redissolve the precipitated carbides eliminating the susceptibility to intergranular attack.

Realizing this inherent weakness of these austenitic steels (Types 302, 304, 316, and 317), the stainless steel metallurgists developed the so-called stabilized grades. Columbium or titanium was added during melting, and these elements combined with the carbon present forming stable carbides of titanium and columbium. When these steels are welded, no harmful chromium carbide precipitation takes place and intergranular corrosion is eliminated. Although the development of these stabilized grades (Types 347 and 321) overcame the intergranular corrosion or weld decay problem, the addition of the stabilizing elements resulted in increased cost.

During the past few years, considerable research has been carried on in an effort to eliminate the poor corrosion-resistant areas near welds without the addition of these stabilizing elements. This research has resulted in the development of the so-called extra low carbon grades; namely, Types 304 ELC

and 316 ELC. It was found that when the carbon content was reduced to .03% maximum, no harmful carbides were precipitated at the grain boundaries in the parent metal adjacent to the weld deposit during the welding operation. This resulted in the elimination of localized intergranular attack or weld decay adjacent to welds in severely corrosive environments. (Figure 1) Their use in welded equipment has eliminated the necessity for the expensive high temperature anneal after fabrication with the accompanying possibility of distortion. The use of these extra low carbon austenitic stainless steels has materially lowered metal costs as they are lower priced than the stabilized grades usually used in welded equipment which could not be conveniently given the high temperature anneal after fabrication.

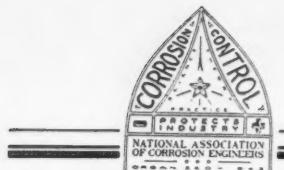
These extra low grade carbon stainless grades are rapidly being accepted and used in the chemical as well as other industries where the corrosive conditions are sufficiently severe to require the use of austenitic stainless steels. Type 304 ELC is recommended for all but the most severe of conditions. Under the most severe conditions, especially where sulfuric and hydrochloric acids are involved, Type 316 ELC, the molybdenum bearing grade is recommended.

When these steels are heated for prolonged periods in the so-called sensitization or carbide precipitation range (1200-1600° F), some carbide precipitation occurs which results in subsequent intergranular attack. However, if the operating temperatures are below 800° F, freedom from intergranular attack at the welded areas is assured with the use of these extra low carbon stainless grades. Companies interested in building welded austenitic stainless steel equipment should thoroughly explore the possibilities of these extra low carbon grades before proceeding.



Figure 1—Type 304 joined to Type 304 ELC stainless by metal-arc welding after five days' immersion in 10 percent nitric—2 percent hydrofluoric acid pickling solution. Note severe intergranular attack on Type 304 parent plate (right) and total absence in Type 304 ELC (left). Both materials were $\frac{1}{8}$ -inch thick and were welded with Type 308 ELC electrodes.

*Chief Chemist, Research Laboratories, Armco Steel Corp., Middletown, Ohio.



NACE News

St. Louis Hears Brown on Aluminum Applications

R. H. Brown of Aluminum Company of America, New Kensington, Pa., addressed 35 members and 25 guests of the Greater St. Louis Section March 20 at a dinner meeting on the subject "Possible Applications of Aluminum as Demonstrated by Corrosion Test Data."

O. C. Mudd, senior corrosion engineer for Shell Pipe Line Corp., Houston, Texas, discussed protective coatings before the Greater St. Louis Section at its February meeting. Mr. Mudd limited his discussion to protective coatings for metals, particularly ferrous alloys.

Protective coatings are an investment whenever their application arrests or retards metal loss of greater value than the coating cost. Corrosion is encountered usually when water is present, Mr. Mudd said.

Basic requirements for a protective coating were outlined by the speaker as follows: 1. Moisture impermeability. 2. Sunlight resistance. 3. Adhesion and



At the speaker's table, St. Louis Section February meeting: Frank W. Whitney, Monsanto Chemical Co., program chairman; O. C. Mudd, Shell Pipe Line Co., speaker, and W. T. Deacon, Solvents and Plastics Co.

bond. 4. Stability in environment. 5. Resistance to organic, fungus, bacteria and marine life attack. 6. Thermal stability.

Surface preparation is of considerable importance and consists of: 1. Removal of foreign materials, mill scale, corrosion products, old coatings. 2. Permeated gases, such as hydrogen, sulphides and others. 3. Removal of moisture.

Methods of surface preparation include: Brushing sand and shot blasting, acid cleaning or pickling, chemical treatment for preferential wetting, inhibiting or etching.

Application methods include brush, spray or flooding. Types of coatings discussed included solvent type, reactive molten and emulsion.

Notices of future meetings of NACE subdivisions are carried monthly under the heading "NACE Calendar" in each issue of CORROSION magazine. Notices for this column should be sent to Central Office.

Corrosion News Deadline:
10th of Month PRECEDING Date of Issue

Conference Papers Are Reviewed at Houston

A review of several St. Louis conference papers and a talk on condensate well corrosion by H. E. Waldrip of Gulf Oil Corp., Houston, Texas, featured the April 11 meeting of Houston Section.

New officers and committee chairmen were introduced by the incoming chairman, Oliver Osborn of Dow Chemical Co., Freeport, Texas. A short business meeting was held during which P. P. Spafford reported on the financial condition of the section.

Six prepared discussions of St. Louis conference papers were presented by Lyle Sheppard, Layton Tugge, Jack Newport, George Holm and Oliver Osborn. Mr. Waldrip spoke on "Practical Aspects of Condensate Well Corrosion," in which he discussed results of a survey of 30 oil companies' methods of corrosion mitigation on some 2000 wells.

"Corrosion Resistant Masonry Construction," a talk by Robert R. Pierce, Pennsylvania Salt Manufacturing Co., chairman of the Philadelphia Section, is the scheduled topic for the meeting of the Houston Section's meeting May 9.

NACE CALENDAR

NORTH EAST REGION—May 10, New York City. Joint meeting with Metropolitan Section.

GREATER ST. LOUIS SECTION—May 15. Dr. R. B. Mears, Carnegie-Illinois Steel Corp., Pittsburgh, Pa., "Causes of Localized Corrosion."

CORPUS CHRISTI SECTION—May 24.

TP-1A—PACIFIC COAST—Meetings scheduled monthly.

May 28-31—AIChE, Regional Meeting, Swampscott, Mass., New Ocean House.

Zinc Corrosion Topic at Corpus Christi Section

R. C. Victor of American Smelting and Refining Co., addressed members of Corpus Christi Section March 23 at a dinner meeting. Twenty-five members and guests attended.

Mr. Victor's topic was "Corrosion Problems in Preparation and Electrolysis of Zinc."

G. Heinemann and George Mills were named to represent the section at the St. Louis conference. Seventeen members of the section attended the meeting of Houston Section held March 14 at Dow Chemical Company Freeport plant.

BOOK REVIEWS

ASTM Standards on Paint, Varnish, Lacquer and Related Products. Prepared by Committee D-1, American Society for Testing Materials. Published by American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., 680 pages, cloth bound, 6 x 9. \$4.85.

A compilation of ASTM Standards on paint, varnish, lacquer and related products as of December, 1949, containing 190 specifications, tests and definitions. Specifications test methods and chemical analysis of pigments cover: white, black, mineral iron oxide, blue, green, yellow and orange, red, metallic, non-hiding and miscellaneous. General pigment test methods include alkalinity or acidity, bleeding, coarse particles, moisture, oil absorption, gravity, tinting strength and mass color of color pigments, water in petroleum products and other bituminous materials and pH of aqueous solutions with the glass electrode. Specifications test methods and definitions of terms relating to drying oils, paint dryers, thinners, shellac, varnish and varnish materials and a section on traffic paint, paint weathering tests, general paint tests are included. New material includes 24 tests and specifications not published in previous compilations.

Recommendations Concernant la Protection des Cables Souterrains Contre la Corrosion. (In French) Approved by the 15th Plenary Assembly of the International Telephone Consultative Committee (C.C.I.F.) Paris, France 1949. Pub. International Telephone Consultative Committee, Palais Wilson, Geneva. 8 1/4 x 11, paper cover, 42 pp. Swiss Francs, 4.25.

Of interest to all concerned with corrosion problems of lead-sheathed cables. Contents include types of corrosion, methods of determining corrosion cause, characteristics of cable sheaths, specifications of casing for added protection, cable-laying procedures, processes to retard corrosion by modifying corrosive medium.

REPORT ON THE 1950 CONFERENCE AND EXHIBITION

Successful NACE Conference Is Held in St. Louis

Lewis B. Donovan Is General Chairman of 1951 Conference Set March 11-15 in New York

Lewis B. Donovan, Consolidated Edison Co. of New York has accepted the post of general chairman of the 1951 NACE Conference which is to be held in New York during March, 1951 and G. E. Seidel of Amercoat Corp., Chicago, Ill., has accepted the post of exhibits chairman, it was announced by Vance Jenkins, NACE president.

Dr. Norman B. Hackerman of the University of Texas, Austin, was named technical program chairman. Dr. Hackerman and Dr. H. H. Uhlig assisted in the preparation of the St. Louis program.

It is possible to have as many as 120 exhibit booths at New York, it was pointed out.

Old and new conference officials met April 6 during the St. Louis Conference to discuss some of the problems of this conference and to lay plans for the 1951 conference and exhibition to be held in New York City during March. Lewis B. Donovan, general chairman of next year's conference, outlined a program calling for a sustained publicity effort about the conference and for steps designed to correct some of the deficiencies noted in the 1950 event.

Among the principal objectives to be achieved, Mr. Donovan explained, is a means of notifying membership earlier of the conference program and committee meetings so arrangements may be made with employers for attendance. Because of the delay in publication of the 1950 official program, many committee members did not know final arrangements for meetings until after they had reached St. Louis.

"March in New York" is Slogan for 1951 Meet

The slogan, "March in New York," will be the keynote of preparations and promotion for the 1951 NACE Conference to be held March 11-15, 1951, at the Statler Hotel, New York City. L. B. Donovan, general chairman of the conference, outlined a program designed to underline the attractions of New York and to invite as wide attendance of NACE members as possible.

One of his principal objectives will be to issue frequent and timely news reports about progress of the plans for the meeting so those who plan to attend will have the information on which to make decisions. Earlier notification of the technical, committee meeting, and other pertinent programs is planned.

1952 Conference Will Be Held in Galveston, Texas

Following a report by A. B. Campbell on the facilities available at both Houston and Galveston the NACE board of directors April 2 instructed Mr. Campbell to advise the hotels in Galveston that NACE would hold its 1952 meeting there in March, exact dates to be set later. Mr. Campbell pointed out that Galveston has adequate space for the annual exhibit, meeting rooms, and that the required number of hotel rooms will be made available. Final dates are to be set later.

Vance Jenkins presented to the board the bids of Los Angeles, San Francisco and Chicago to be the scene of future NACE conferences.

Compliments on a well-organized, smoothly-functioning 1950 conference were volunteered by many attending the St. Louis meeting April 4-7 to J. Pat Casey, General Chairman, and Dr. Aaron Wachter, Technical Program Chairman and their assistants, and O. E. Murray, Exhibits Chairman. Exhibits were more diversified than at any other previous conference of the National Association of Corrosion Engineers, and the general excellence and value of the exhibits frequently was mentioned favorably.

Final registration was 942, the largest at any NACE conference so far, and there were 54 women guests to take part in the entertainment provided for them by the local St. Louis Section committees.

Symposia Attract Many

Attendance at symposia presentations was consistently good, and the two round-table sessions the last day of the meeting, April 7, attracted many in spite of the haste to depart for home for the Easter holiday.

Numerous discussion records were turned over for processing by Central Office to collect material eventually to be published in CORROSION in connection with the technical papers.

The annual Fellowship Hour was an outstanding success and the banquet Thursday, April 6, was featured by the usual formalities of the presentation of new officers, the annual NACE awards to Messrs. O. C. Mudd and R. H. Brown. Entertainment was provided by the St. Louis Policemen's Trio.

Committee Day Popular

Allocation of the majority of committee meetings to April 3, the day immediately preceding the official opening of the conference, was a popular innovation. This enabled committee members for the most part to attend necessary committee meetings as well as hear some of the technical program and visit exhibits especially interesting to them.



Corrosion engineers attending presentation of the paper "The Influence of Stress on Corrosion" by Julius J. Harwood, Office of Naval Research, Washington, D. C., during the Sixth Annual Conference of the National Association of Corrosion Engineers, St. Louis, Mo., April 4-7, 1950.

New Procedure for Selecting NACE Award Recipients Is Presented at Board Meeting

Numerous decisions were reached during the April 2 meeting of the NACE Board of Directors at the Jefferson Hotel, St. Louis. Among the most significant moves was the decision to hold the 1952 conference and exhibition in Galveston, Texas. F. L. LaQue, speaking as chairman of a committee consisting of himself, Dr. J. M. Pearson and Dr. F. N. Speller outlined a proposed procedure for the selection of NACE award winners. The committee's recommendations were taken under advisement and are to be acted on later.

Some other important actions included:

The president was asked to name members of a finance committee for the association whose initial duty would be to advise the board on an investment policy for surplus association funds.

No decision was reached on whether or not use of the official NACE emblem would be authorized on business printing of association members.

The questions respecting exchange of copies of CORROSION, NACE publications and NACE technical committee reports was referred to the Publications Committee for consideration, and it was asked to suggest a policy for board decision.

The tenures of office of R. H. Lynch, North East Region Director and I. C. Dietze, Western Region Director were set as terminating in 1951 and 1952 respectively, a solution agreeable to the regions and persons concerned.

Secretary A. B. Campbell was instructed to arrange for a booth at the Houston Industrial Exposition in May and to arrange for manning the booth with Central Office and Houston Section members during the week's exposition.

The price to non-members of the current Interim Report of TP-3—On Anodes for Impressed Currents was set at \$5.

E. P. Noppel, chairman of the policy and planning committee presented the proposed amendments to the articles of organization which were considered, but not voted on, at the general association meeting Tuesday, April 4. Voting on the amendments will be by letter ballot. Revised by-laws were adopted by the board as presented by Mr. Noppel.

Dr. Mars G. Fontana, chairman of the technical practices committee announced that Dr. Pearson had accepted the chairmanship of TP-4—Minimum Current Requirements for Cathodic Protection, that the president of NACE write members of the committees letter of appreciation for their work. In order to expedite publication of committee work, Dr. Fontana proposed the publication in CORROSION of progress reports, that a directory of TP officers, members and scopes be published annually in CORROSION and that TP committees be encouraged to submit papers. The board's action on some of these points was that existing policy on TP reports would be followed, that a list of TP officers, members and scopes would be published separately at least to begin with, and that Dr. Fontana arrange through conference with the technical program chairman for the 1951 conference for a symposium to

be presented by the Technical Practices Committee.

The board also decided that lists of publications available from NACE should be included in general mailings to memberships during the year and that the revised articles of organization and by-laws should be published in CORROSION when approved, as well as in reprint form.

Mr. Vance Jenkins, reported the University of California at Los Angeles was holding a course on corrosion for credit and non-credit and that 90 students who applied for the course could not all be accommodated. It also was learned that Case Institute of Technology was planning a short course in corrosion this summer and that Stevens Institute was planning to offer a course in corrosion next year in which NACE was asked to participate. It also was announced that universities in Oklahoma and Kentucky were adding corrosion studies to their curricula.

Mr. L. A. Baldwin offered NACE the use of a table at the Johns-Manville Company booth at the American Chemical Society show in New York at which NACE literature would be made available.

J. Pat Casey, Jr. general chairman of the St. Louis Conference gave a report of his activities, and presented a budget for the conference, which was accepted by the board. Mr. Casey stated the exhibition of motion pictures for this year's exhibit was cancelled, and he suggested an educational bulletin be prepared for distribution by NACE to prospective exhibitors, giving the advantages of showing motion pictures of their products at the annual conferences.

Case Institute to Hold Corrosion Short Course

Case Institute of Technology, Cleveland, Ohio, will hold a short course in corrosion during September, 1950, according to plans announced at St. Louis before a meeting of the National Association of Corrosion Engineers' board of directors Friday, April 7. The board agreed to participate with Case in presentation of the short course to the extent of giving assistance with publicity and extending official NACE approval of the undertaking.

R. B. Hoxeng, a member of the Case faculty, and of NACE, appeared before the board to present the proposal. Mr. Hoxeng will be in general charge of the program for the short course.

Specific information respecting the content of the course, the exact dates and fees are expected to be available for publication soon.

Members of the American Petroleum Institute Subcommittee on Internal Corrosion of Crude Oil Pipe Lines and Tanks present at the NACE meeting at St. Louis were asked to attend a meeting at 5 p.m. April 5 at St. Louis.

NACE Growth Cited in President's Annual Report

By R. B. MEARS
President, NACE

Every year at the annual meeting of this association the president is expected to give a report on the state of the NACE. This report corresponds to the president of the United States' annual State of the Nation talk. I hope it will never be necessary, however, for the president of NACE to dwell on proposals for giving more and more to members who contribute less and less. In the NACE the return that any member gets corresponds rather closely to how much he contributes. Our organization would collapse immediately without the active support of the members. Its future progress is dependent directly on the amount and quality of this support. During the past year our association has continued to grow. On February 28 of the year 1949 the membership of the NACE was distributed as follows:

1596 Active Members
20 Junior Members
257 Associate and Corporate Members
1873 Total Members

On February 28 of 1950, the membership stood as follows:

1924 Active Members
39 Junior Members
255 Corporate Members
2218 Total Members

The net gain in total membership amounted to 18 percent.

Similarly, there was a net gain in the income, expenses and net profit of the association for the year ending December 31, 1949 as compared to those from

the previous year. These figures are given below:

Total income	\$125,957.62
Total expenses	113,138.48
Net gain	12,819.14

This corresponds to a total income of \$88,694.42 last year, with a net gain of \$8,943.99.

Thus, 1949 was a year of continued growth for our association. It was a year in which our membership first passed the two thousand mark and our income first exceeded one hundred thousand dollars.

Regions and Sections

The activity of regions and sections has been increasing. This is of greatest importance since such activities form the basis of a strong organization. Particularly noteworthy was the highly successful meeting of the Southwest Region which was held in Dallas in October of 1949. This meeting was attended by 285 people and illustrates what can be accomplished by careful planning and good organization. Other successful regional meetings were held by the North-East and South-East Regions.

New sections were formed at Pittsburgh, Baltimore, Salt Lake City and West Texas. Thus, the total number of sections has increased from 12 to 16. It is hoped that several additional sections will be organized in the near future.

Publications

At the beginning of 1949 a larger size was adopted for CORROSION magazine. This new size has proved to be an asset in obtaining advertising for the maga-

zine. The total number of paid subscriptions to the magazine has increased from 1994 to 2704. During 1949, net gain from publications was over three thousand six hundred dollars as compared to a net loss of about eighteen hundred dollars in 1948. These publications included not only CORROSION magazine but also the Cathodic Protection Symposium, O. C. Mudd's manual on Cathodic Protection, and the 1945 Corrosion Abstracts. These publications are valuable additions to the corrosion literature and form another unique contribution of our association. It is fitting at this time to pay tribute to people who have been responsible for the success of these publications: Dr. Ivy M. Parker, Mr. N. E. Hammer, Dr. F. N. Alquist and other members of the Publication Committee and the Editorial Review Committees. The work involved in getting out Corrosion magazine and the other publications is tremendous. We all owe these people a great deal for their diligence and skill which has made these publications possible.

Technical Practices Committee

Under the chairmanship of Dr. Mars G. Fontana, the scope of our technical committees has been further increased. A final report on the work of TP-1 on condensate well corrosion has been prepared and is now being edited for publication. Reports covering preliminary results of field tests by TP-2 and TP-3 have also been written and will be published soon. TP-12 on grounding practices has completed its initial assignment

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and is now starting work on another problem. New committees on Corrosion Control in the Transportation Industry, Identification of Corrosion Products, Annual Losses Due to Corrosion and Instruments for Corrosion Measurements have been formed and their work is under way.

Technical committee activity is an important part of the scope of the NACE. Possibly no other activity of the Association is of greater importance to its continued growth.

Education

Our association embarked on a new venture in 1949. Spark-plugged by the South West Region, we entered the educational field with a Short Course in Corrosion under the direction of Dr. Norman Hackerman at Texas University. This venture was highly successful. Over one hundred people attended the course. This excellent response resulted in the decision to continue the short course idea in 1950. It is planned to hold two or three short courses next summer.

Modernization of Articles of Organization and By-Laws

The Policy and Planning Committee, under the leadership of Mr. E. P. Noppel continued the considerable task of revising the Articles of Organization and By-Laws, which had been started under the chairmanship of Dr. Trueblood the year earlier. As you know, the main revisions to the Articles of Organization were approved by letter ballot of the membership this year. Some additional revisions and the revised By-Laws remain to be voted upon.

Annual Conference and Exhibition

It is difficult at this time to evaluate

our 1950 Convention and Exhibit since it is just getting started. Some facts are even now obvious. This year for the first time we adopted the policy of having a "Committee Day" on Monday preceding the formal opening of the meeting. It was, I believe, a definite forward step. The exhibition is bigger and better than ever before—that there is no question. The technical program also seems to have hit a new high. For these accomplishments our thanks are due to Mr. J. Pat Casey, general chairman of the conference, Dr. A. Wachter, the technical program chairman and Mr. O. E. Murray the exhibition chairman. They were ably assisted by the local arrangements committee under the chairmanship of Mr. Otto H. Fenner.

General

The past year has been a very interesting one for your President. He has been particularly gratified to see how smoothly the business and activities of our Association are being handled. Our Central Office staff has functioned with increased efficiency under our very able Executive Secretary, Berry Campbell. To Berry more than to any other one individual belongs the credit for the advances of the past year. We are fortunate indeed to have such able Central Office personnel.

The interest and support of all our various officers, committees and members in general have been notable. So long as such enthusiasm continues, our association will progress. Let it be hoped that the important contributions the NACE has made in the past will be dwarfed by those yet to come. If we all work to that end it is certain to be achieved.

More Than 300 Attend Pipe Line Round Table

Attendance by over 300 persons at the Pipe Line Corrosion Round Table session held at the DeSoto Hotel, St. Louis during the 1950 Conference under the chairmanship of F. J. McElhatton made this one of the outstanding sessions of the conference. It had been feared that the necessity of removing the session to the hotel from the headquarters hotel vicinity might hurt attendance.

The session, which got under way about 9 a.m. Friday, April 7, was still going strong at noon when transportation commitments forced suspension of the program.

Many General Corrosion Problems Are Presented

A large number of discussions were recorded for canvass and compilation into a manuscript for publication in CORROSION during the General Corrosion Problems Round Table discussion held Friday, April 7, at Hotel Jefferson, St. Louis.

F. L. LaQue, chairman, and others who assisted him in presentation of the discussion will canvass the remarks recorded, compile them, and present answers to questions.



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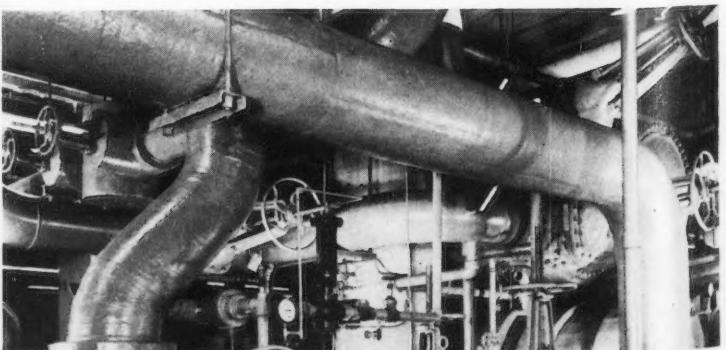
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Attend Treasurer O. C. Mudd's Table Report Shows Progress

Treasurer O. C. Mudd's annual report to the board of directors at its meeting Sunday April 2 at the Jefferson Hotel St. Louis showed 1949 gains in net worth to \$38,572 from the \$23,037 recorded for 1948, for the National Association of Corrosion Engineers. Membership increased from 1737 in 1948 to 2133 in 1949. Combined revenue for 1949 was \$125,168, combined expense \$109,631, and net gain \$15,537 for the year.

Mr. Mudd's report follows:

Membership	1948	1949	% Inc.
Active	1,473	1,835	24.6
Junior	19	37	95.0
Corporate	185	197	6.5
Associate	60	64	6.7
Total	1,737	2,133	
Membership Activity			
Revenue	\$25,678	\$36,679	
Expense	22,192	37,267	
Gain (Loss)	3,486	(588)	
Expense Includes			
Salaries	14,540	23,754	
Corrosion Magazine			
Revenue	\$49,278	\$63,656	
Expense	45,712	59,629	
Gain (Loss)	3,566	4,027	
Expense Includes			
Salaries	11,301	12,042	
Annual Conference			
Revenue	\$19,240	\$24,833	
Expense	10,159	12,735	
Gain (Loss)	9,081	12,098	
Combined Revenue	\$94,196	\$125,168	
Combined Expense	78,063	109,631	
Gain (Loss)	16,133	15,537	
Office Equip. Value Purchased	\$5,152	\$3,864	
Total	7,046	10,910	
Depreciation	628	1,472	
Money Invested			
Treasury Notes		\$20,000	
NET WORTH	\$23,037	\$38,572	

Dr. Speller Badly Hurt In Fall From Tug Boat

Dr. F. N. Speller, while making some inspections in connection with the paper on Diesel corrosion which he and F. L. LaQue of The International Nickel Co., Inc., prepared for presentation at the St. Louis conference fell from the deck of a boat to a concrete dock and was seriously injured.

Mr. LaQue said Dr. Speller's injuries, which included fractured legs and other broken bones, were likely to incapacitate him for some time.

St. Louis Hears Berry

"Corrosion Engineering: From Laboratory to Field," was the topic of an address scheduled by Dr. N. E. Berry, Servel, Inc., Evansville, Ind. to the Greater St. Louis Section at its April 20 joint meeting with the Engineers' Club and the American Institute of Chemical Engineers at the Engineers' Club, St. Louis. Dr. Berry discussed corrosion engineering as a professional activity.



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Officers and Directors at Annual Banquet in St. Louis, Mo.



Officers and directors at annual banquet, Sixth Annual Conference National Association of Corrosion Engineers, St. Louis, Mo., April 4-7, 1950, left to right: J. M. Pearson, Sun Oil Company, Philadelphia, Pa.; E. D. Verink, Jr., Aluminum Co. of America, New Kensington, Pa.; Tom L. Holcombe, Holcombe & Stearns, Inc., Shreveport, La.; O. C. Mudd, Shell Pipe Line Co., Houston, Texas; R. H. Brown, Aluminum Company of America, New Kensington, Pa.; F. J. McElhatton, Panhandle Eastern Pipe Line Co., Kansas City, Mo.; Vance N. Jenkins, president NACE 1950-51, Union Oil Company of California, Wilmington, Calif.; R. B. Mears, past president NACE, Carnegie-Illinois Steel

Co., Pittsburgh, Pa.; N. E. Berry, Servel, Inc., Evansville, Ind.; R. A. Brannon, treasurer NACE, Humble Pipe Line Co., Houston, Texas; A. A. Wachter, Shell Development Co., Emeryville, Calif., technical program chairman 1950 conference; O. E. Murrey, Midwestern Engine & Equipment Co., Tulsa, Okla., exhibits chairman, 1950 conference; J. P. Casey, Jr., The Crane Co., Chicago, Ill., general chairman, 1950 conference; H. D. Murray, Cren-Ray Plastic Products Co., Midland, Texas; F. L. LaQue, The International Nickel Co., Inc., New York, N. Y.; Mars J. Fontana, Ohio State University, Columbus, Ohio; Dr. Ivy M. Parker, Plantation Pipe Line Co., Bremen, Ga.

Three New Technical Practices Committees Formed

Three new technical practices committees were approved by 18 members of the Technical Practices Committee meeting at St. Louis, April 5, during the

Exhibitors' Ideas on Improvements Given

Exhibitors at the 1950 NACE Conference in St. Louis were generally pleased with the results achieved and with arrangements during the conference. This point of view, together with several constructive criticisms and recommendations for the 1951 conference at Hotel Statler in New York was developed at a meeting of exhibitors and NACE officials April 7, last day of the conference.

Specifically approved were arrangements calling for afternoon symposia to open at 2:30.

Numerous recommendations made by the exhibitors included:

1. A cross-indexed guide to exhibitors and products should be provided.
2. A directory listing exhibitors and names of booth staffs should be provided.
3. Booth numbering system should be designed so every booth's number is prominent.
4. Direction signs should indicate booth numbers.
5. All exhibit space in one room is preferable.
6. Motion pictures are acceptable.
7. Young engineers should be especially encouraged to visit the booths.
8. Adequate advance publicity should be provided for New York conference.
9. Trade journals and technical publications should be sold space on same basis as other exhibitors.
10. The price of one or two registrations should be included in booth price for staffs of exhibitors.
11. Exhibitors should be pre-registered.
12. Special attention will be needed in New York for admission to exhibit by pass only, and some provisions should be made for issuance of limited number of passes by exhibitors.

An analysis of the 1950 exhibits prepared by G. E. Seidel, chairman of the 1951 Exhibit Committee showed geographical distribution of exhibitors as follows in percentages: East 20, South 6, Midwest (including Oklahoma) 33; Far West 1.

annual conference. They are:

TP-16—Electrolysis and Corrosion of Lead Sheathed Cable, Irwin C. Dietze, Dept. of Water and Power, City of Los Angeles, Cal., chairman.

TP-17—Standardization of Procedure for Measuring Pipeline Coating Conductances, W. E. Huddleston, Huddleston Engineering Co., Bartlesville, Okla., chairman.

TP-18—Internal Corrosion in Storage and Transportation of Petroleum, L. G. Sharpe, Humble Pipe Line Company, Houston, Texas, temporary chairman.

New Chairmen Named

Changes in chairmanships of two committees were announced:

TP-4—John M. Pearson, Sun Oil Co., Newton Square, Pa.

TP-13—F. A. Rohrman, University of Colorado, Boulder, Colo.

Mars G. Fontana proposed that technical committees sponsor symposia at next year's conference in New York. Plans of two committees to sponsor symposia were approved.

The committee also agreed to continue the use of the Technical Committee Activities page in CORROSION and prepared a schedule.

Reports Are Discussed

Publication of TP reports and digests in CORROSION, as well as distribution to members of the committee also was discussed. The committee approved plans for publishing by Central Office of a directory of TP membership which will be sent to all committee and sub-committee members.

Following a suggestion by W. P. Noser, the group also acted favorably on a proposal to request Central Office to print and distribute copies of minutes for all committee members.

New Investigations Are Being Weighed by TP-1

Several reports on work under way by this committee were presented April 3 at St. Louis, Mo., during the sixth annual NACE conference. Attending the meeting were 52 interested in the corrosion of oil and gas well equipment.

H. E. Waldrip began his term as the committee's first vice-chairman.

Ernest Kartinen, Signal Oil and Gas Co., Los Angeles, Cal., of the Pacific Coast Sub-Committee, said many corro-

sion engineers in that area were concerned over the sale and application of "gadgets" which may prove ineffective or actually accelerate corrosion attack.

R. C. Buchan, Humble Oil and Refining Co., Houston, Texas, reported that the committee's previous work in testing alloys and the development of inhibitors has reduced corrosion of condensate wells but that problems encountered in wells where the tubing was set on packers demand attention. Mr. Buchan also suggested that efforts be made to obtain more complete data on lasting effectiveness of inhibitors and on tubing corrosion records.

H. L. Bilhartz, Atlantic Refining Co., Dallas, Texas, presented a preliminary report on the information obtained by his sub-committee studying high-pressure, high gas-oil ratio sweet oil wells.

R. S. Treseder, Shell Development Co., Emeryville, Cal., was named chairman of a sub-committee to study the type of hydrogen sulphide condensate well corrosion experienced in a Pincer Creek, Canada, field.

More Anode Tests Are Planned by TP-2 Group

Aluminum, magnesium and zinc anode tests by three members of Technical Practices Committee 2—Galvanic Anodes were planned soon at a meeting of the group April 3 at St. Louis. Ten members and 35 guests were present to hear reports on tests now underway by six members of the committee. Some members participating in current tests plan to dig up anodes for examination in the near future.

Lyle Sheppard, Shell Pipe Line Corp., Houston, was appointed chairman of a sub-committee to correlate field data on anodes installed by companies on operating lines.

Third Year Inspections Reviewed at TP-3 Meet

Third year inspections of Technical Practices Committee 3 on Anodes for Impressed Currents have yielded results which tend to substantiate conclusions previously reached and published in the committee's first interim report, A. W. Peabody, Ebasco Services, Incorporated, Jackson, Miss., reported to 27 members

and registrants of the committee meeting April 3 at St. Louis, Mo., during the sixth annual conference of NACE. J. Paul Oliver, National Carbon Division, Union Carbide and Carbon Co., Cleveland, Ohio, distributed reports to committee members prepared by Karl S. Hagins, Colorado Interstate Gas Company, Colorado Springs, Colo., on committee tests now being conducted.

Because tests now being made on the committee's project will be completed next year the committee considered future plans, including anode installation and operation in marshy ground, backfill methods and positioning ground beds for greatest efficiency.

Mr. Oliver acted as chairman in the absence of and at the request of Donald H. Bond, chairman.

NBS Plan to Suspend Underground Tests Is Opposed by Group

Opposition to the proposed termination by the National Bureau of Standards of its long-time program on underground corrosion was voiced by members of the Inter-Society Corrosion Committee of NACE at its meeting April 6, during the 1950 Conference at St. Louis. The committee adopted a motion proposed by G. H. Young, Mellon Institute, Pittsburgh, Pa., in which reconsideration by NBS of its decision was requested and the facilities, advice and assistance of the group offered NBS to avoid discontinuing the studies.

The resolution will be presented to the bureau and officers or members designated by officers of the committee have been instructed to discuss with officials of the bureau means for continuing the research.

During the discussion preceding adoption of the motion it was pointed out that the bureau's extended testing program has kept numerous specimens under observation for long periods and discontinuance now would mean the loss of this experience.

The new constitution and by-laws of the committee are apparently going to meet the approval of the requisite two-thirds of the membership, A. B. Campbell, secretary, reported.

Sam Tour, of Sam Tour, Inc., New York City, was elected president, and H. P. Godard, Aluminum Laboratories, Ltd., Kingston, Ontario, Canada, was elected vice-president.

Numerous reports, to be submitted in writing later, were made by delegates concerning the corrosion activities of their respective organizations.

Standing Committee Chairmen Are Named

The new board of directors of NACE for 1950-51 held its first meeting on the afternoon of April 7 at Hotel Jefferson, St. Louis.

Named members of standing committees were:

Thomas F. P. Kelly, chairman, advertising committee.

E. P. Noppel, renamed chairman of the policy and planning committee.

Mars Fontana, renamed chairman of the technical practices committee.

Ivy M. Parker, renamed chairman of the publications committee.

Norman Hackerman renamed chairman of the education committee.

The board agreed the next meeting of the executive committee would be held in June or July, probably in Chicago or St. Louis, the date and place to be determined later.

The secretary, A. B. Campbell, was authorized to select a date with as few conflicts with other organizations as feasible to be recommended for the 1952 meeting of the association at Galveston, Texas, preferably in the first half of March.

Changes in officers, or changes in addresses of officers should be brought to the attention of Central Office by secretaries of NACE regions and sections.

Changes will be made as soon as possible in the monthly list "Directory of Regional and Sectional Officers."

CIMO Metals Division Moves in Netherlands

Central Institute for Material Research (CIMO) Metals Division, has been moved from Nieuwe Laan 76, Delft to Lange Kleiweg 22, Rijswijk, between Delft and Rijswijk, where other divisions of CIMO are also located.

Mailing address is P. O. Box 49, Delft. Telephone number is 2490, Delft.

Members of NACE from California at the St. Louis Conference attended a luncheon there April 5.

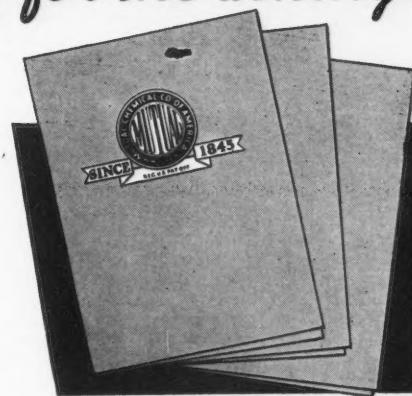
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- Serial No. 56—"Properties of Technically Important Hexavalent Chromium Compounds."

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Committee Reviews Publication Exchange Policy

The annual meeting of the publications committee at St. Louis was attended by Dr. Ivy Parker, chairman, Dr. F. N. Alquist, Miss Marguerite Bebbington, E. R. Stauffacher and N. E. Hamner. The meeting was held in two sessions.

Numerous items on the agenda included.

The consensus of the committee was that exchanges of CORROSION for other periodicals, publications for other publications and technical committee reports for reports of other groups and associations would have to be considered each case on its merits and that the committee would undertake to screen the current exchanges of CORROSION for unneeded periodicals, and keep members of the committee advised in the future when an exchange was under consideration.

Many Requests Made

The committee acted on instructions from the board of directors given April 2 when A. B. Campbell, executive-secretary asked for a decision by the board relative to exchanges of all kinds for NACE publications. Mr. Campbell said that there was a growing number of requests for exchanges with CORROSION for other periodicals, and for free or review copies of NACE publications. He asked that he be given some assistance in making decisions on whether or not these requests should be honored.

Dr. Parker, during the publications committee discussion on this topic, pointed out that considerations in addition to the intrinsic worth of the publications received in exchange for NACE publications should be considered. In many cases, she said, the value to the association of getting NACE publications into the hands of organizations would be of far greater value to the association than anything printed received in return.

Mr. Stauffacher, pointing to the experiences of his company in the purchase of equipment, expressed the opinion that many manufacturers either were totally unaware of certain bad practices corro-

sion-wise, or chose to ignore the lessons in mitigation already well known. Dr. Alquist, in the same area, expressed the belief that many articles of pointed value in specific industries were never seen by persons in those industries because periodicals serving those industries failed to take advantage of the opportunity to reprint material from CORROSION that would be beneficial.

Dr. Parker then said that the problem appeared to be one which could be considered logically by the Inter-Society Corrosion Committee and that she would undertake to go into it with the committee.

Correspondent Problem

The proposal by a person in England who offered for a fee his services in translating foreign-language articles on corrosion for publication in CORROSION tentatively was considered to be unacceptable until further details are available. Miss Bebbington expressed the belief this service would be redundant with the existing abstract publication.

Standards Considered

The managing editor, Norman E. Hamner, was instructed to consider a set of standards for periodicals established by the American Standards Association with the view of recommending adoption or rejecting the various standards proposed and prepare a report on the problem for consideration by the committee. Changes, if made, will not become effective before January, 1951.

News of association doings will be indexed separately on the contents page, beginning with the May, 1950 issue, it was decided, in response to a request.

5-Year Index

Proposal by Mr. Hamner for the form of the proposed 5-year index to the technical material published in CORROSION was tentatively approved by the committee. A draft of the proposed form is to be submitted to committee members for consideration. If approved, members

of the NACE abstract committee will be asked to cross-index the material for Volumes 1 through 5 and the editorial review committee for material in Volume 6.

The proposed index would be a table using the first two places of the NACE abstract index as the horizontal ordinate, with the article titles, and authors as the vertical ordinate.

A time schedule for the completion of the index was proposed.

E. R. Stauffacher presented a first draft of the revised rules for presentation and publication of technical material by NACE prepared by his committee. This draft will be circulated among members of the rules committee and publication committee for comment before final acceptance.

Members of the publications committee also will be sent copies of the revised abstract index which will be compiled by the abstract committee. Miss Bebbington's committee has reached decisions on the remaining obstacles to presentation of the complete index.

Complying with instructions of the board of directors, it was reported that future publications of NACE all will bear on their front cover the association emblem.

A schedule of introductory pages for future publications of technical practices committee reports was approved.

NACE MEMBERS

IF You Change Addresses

IF You Change Company Affiliation

IF You Change Positions

Please notify the Central Office NACE, 919 Milam Building, Houston 2, Texas, so that you will get CORROSION without delay and that association records can be kept abreast of your progress.

THANKS!



Members of Technical Practices Committee 1, on Corrosion of Oil and Gas Well Equipment, shown at their meeting during the Sixth Annual Conference of the National Association of Corrosion Engineers, at St. Louis, Mo., April 4-7, 1950. Seated at the far end of the table facing the camera are Ted S. Zajac, Shell Oil Co., Houston, Texas, H. E. Waldrip, Gulf Oil Corp., Houston, Texas, chairman and vice-chairman respectively.

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Nine Topics Listed for Gordon Research Conference on Corrosion on July 24-28

Nine topics have been scheduled for discussion during the Gordon Research Conference on Corrosion July 24-28 at Colby Junior College, New London, New Hampshire. The conferences, formerly known as the Gibson Island Research Conferences, sponsored annually by the American Association for the Advancement of Science, will be held from July 26 to September 1.

Program for the corrosion conference was given as follows by W. George Parks, director; Rhode Island State College, Kingston, Rhode Island:

Norman Hackerman, chairman; F. W. Fink, vice-chairman.

Electrical Measurements in Corrosion

July 24—J. H. Uhlig, "Contact Potentials"; D. MacGillavry, Jr., "Metal-Solution Interface Potentials."

July 25—W. D. Robertson, "Double Layer Capacity at an Anode"; A. J. deBethune, "Overvoltage."

July 26—R. H. Brown, "Polarization"; F. L. LaQue, "Polarization in Flowing Solutions."

July 27—H. D. Holler, "Potentials of Galvanic Couples"; K. G. Compton, "Potentials of Coated and Inhibited Metals."

July 28—J. M. Pearson, Summation: "The Working Electrode in Corrosion Processes."

No Proceedings Issued

The Gordon Research Conferences were established to stimulate research in universities, foundations and industrial laboratories. Meetings are informal, and sufficient time is available for discussion. Meetings are held mornings and evenings, with the exception of Friday evenings, and afternoons are free for recreation or participation in discussion groups.

"It is hoped each conference will extend the frontiers of science by fostering a free and informal exchange of ideas between persons actively interested in the subjects under discussion. The purpose of the program is not to review the known fields of chemistry, but primarily to bring experts up to date as to the latest developments, analyze the significance of these developments and to provoke suggestions as to the underlying theories and profitable methods of approach for making new progress," Mr. Parks says.

No publications are prepared as emanating from the conference and all information presented may not be used without specific authorization of the contributor.

Requests for information should be addressed to W. George Parks, Director, Department of Chemistry, Rhode Island State College, Kingston, Rhode Island. From June 20 to September 1, 1950, mail should be addressed to Colby Junior College, New London, New Hampshire.

Published during January, 1950, by the National Bureau of Standards was CS161-49 "Standard Grade" Hot-Dipped Galvanized Ware (Coated After Fabrication), 11pp., 5 cents, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C.

Section and region secretaries are urged to use forms provided by NACE for reporting meetings and attendance at meetings to Central Office and CORROSION magazine.

World Petroleum Meet Provisional Program Set

A copy of the provisional program for the Third World Petroleum Congress to be held at The Hague, May 28-June 6, 1951, has been received by NACE. Aim of the meeting is stated to be to focus attention on the present status of science and technique in the petroleum industry.

No reports will be read during sectional meetings. All scientific contributions will be sent to the members in printed form before March 1, 1951. At the meeting the general reporter will read a summary of the reports submitted, after which these will be put forward for discussion.

Master Section 8: Construction of Equipment; Materials, Corrosion, has a subsection to be devoted to materials, corrosion. Further breakdown is not provided.

Other information about the congress in the program includes a statement that proceedings, discussions and conclusions will be published for each section and that copies of these will be available for 7.50 guilders per volume. Subscription to the congress is 25 guilders for members and 15 for ladies accompanying them.

Numerous industrial excursions are contemplated to coal mines, oil refineries, laboratories, steel works, docks and harbors, besides tourist excursions.

Organization committee for the congress consists of G. A. Tuyl Schuite-maker, chairman; A. A. G. Schiefer-decker, vice-chairman; J. A. Beukers, treasurer; J. W. Zwartsenberg, secretary.

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Informative Papers on Zinc Industry Are Given

Several informative papers of interest to the zinc industry were delivered at the 32nd annual meeting of the American Zinc Institute, Inc., at St. Louis, Mo., April 11, 1950.

Among the remarks of corrosion interest reported were the following:

By J. R. Freeman, Jr., Technical Manager, The American Brass Co.: When experience over the years showed Yellow Brass pipe subject to dezincification and failure by corrosion in more corrosive waters, Red Brass, of nominal composition 85 percent copper and 15 percent zinc, was found to have greatly superior corrosion resistance and was recommended and used in place of the alloy of higher zinc content.

The development of solder-type fittings for copper tube has had an even greater influence, and, in fact, brought about revolutionary changes in the water supply systems for homes as well as larger buildings. As a result of this development, Yellow Brass pipe has been abandoned and Red Brass is used only in commercial or monumental structures where its superior corrosion-resistance is required.

By F. G. White, Technical Director, Granite City Steel Company: Cold reduction of tin plate replaced the costly pack rolling method in eight years. Electrolytic tin plate in eight years accounts for 60 percent of all tin plate made. Continuous galvanizing of sheets is progressing so rapidly that it will not need eight years to see the process in general use.

Now that efficient methods have been worked out for galvanizing sheets, it would seem natural to expect that additional new lines will be put in operation as soon as the automotive demand (for cold rolled sheets) is satisfied. Perhaps galvanized sheet production will again equal cold rolled sheet production.

By R. G. Kenly, Manager, Metal Division, The New Jersey Zinc Sales Co.: In

the very early days of the die casting industry little attention was paid to zinc alloys. However, because many castings showed a perverse and alarming tendency to crack and crumble after a few years' service, far thinking members of the industry developed the presently used Zamak alloys.

The American Zinc Institute and American Die Casting Institute got together to have C. R. Maxon, of The New Jersey Zinc Company, go to the Canal Zone as representative of both institutes. Armed with weapons against the prejudice against zinc die casting in the zone, Mr. Maxon met with cooperation from the people there and left with knowledge the Canal Zone authorities were convinced they could order zinc die castings against existing government specifications and be assured of their performance.

ASTM Annual Meeting Set in Atlantic City During Week of June 26

Six symposia have been announced so far for the 53rd Annual Meeting of the American Society for Testing Materials in Atlantic City the week of June 26. Symposia likely to be of especially corrosion interest include: Effect of Sigma Phase on the Properties of Metals at Elevated Temperatures, Corrosion and Erosion of Gas Turbine Materials, The Role of Non-Destructive Testing in the Economics of Production, and Identification and Classification of Soils.

Many other papers also will be presented dealing with cementitious materials, plastics, timber, aluminum and ferrous metals.

During the week hundreds of technical committees will complete work on standards and report research development.

The Ninth Exhibit of Testing Apparatus and Related Equipment will be in

progress as well as the society's biennial photographic exhibit.

The 1950 Marburg Lecture will be given by Dr. Wallace R. Brode, associate director of the National Bureau of Standards, on spectroscopy as allied to testing and analysis of materials.

Canadian Group Studies

Two Corrosion Projects

The Protective Coatings Division of the Chemical Institute of Canada discussed at the March 17 regional meeting of the institute at Montreal the feasibility of conducting a literature search on galvanic corrosion, the findings to be published in booklet form. As an alternative the division is considering the possibility of conducting a practical survey of corrosion conditions and means of overcoming them in Canadian industrial plants.

The division recently held a one-day symposium at which five speakers gave papers on corrosion and corrosion prevention.

Electroplaters' Meeting

Scheduled for June 12-15

Two sessions on smoothing and leveling processes in electroplating, one on research programs, one on mechanical finishing methods and a general topic session are scheduled for the 37th Annual Convention of the American Electroplaters' Society and Fourth International Conference on Electrodeposition (in collaboration with the Electrodepositors' Technical Society of Great Britain). The meeting will be held June 12-15, 1950, at Hotel Statler, New York. Members of the National Association of Electroplaters and Stereotypers have been invited to participate in the general topics session.

Thermodynamics and Kinetics Committee to Hold Meeting in Italy

The second meeting of the Committee of Electrochemical Thermodynamics and Kinetics will be held September 18-21, 1950, at Milan and Pallanza, Italy.

Prof. Roberto Piontelli of the Milan Politecnico is in charge of arrangements. Inquiries may be addressed to him, Dr. P. Van Rysselberghe, University of Oregon, Eugene, Oregon, or to Dr. Marcel Pourbaix, University of Brussels, Belgium.

The committee was formed to facilitate and promote international cooperation in investigations of electrochemical thermodynamics and kinetics.



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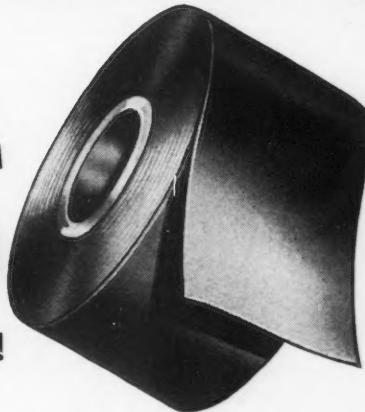
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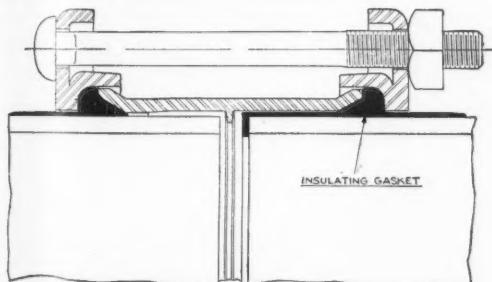
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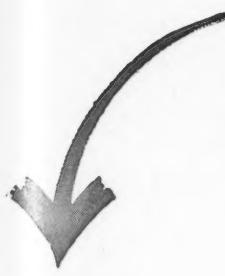
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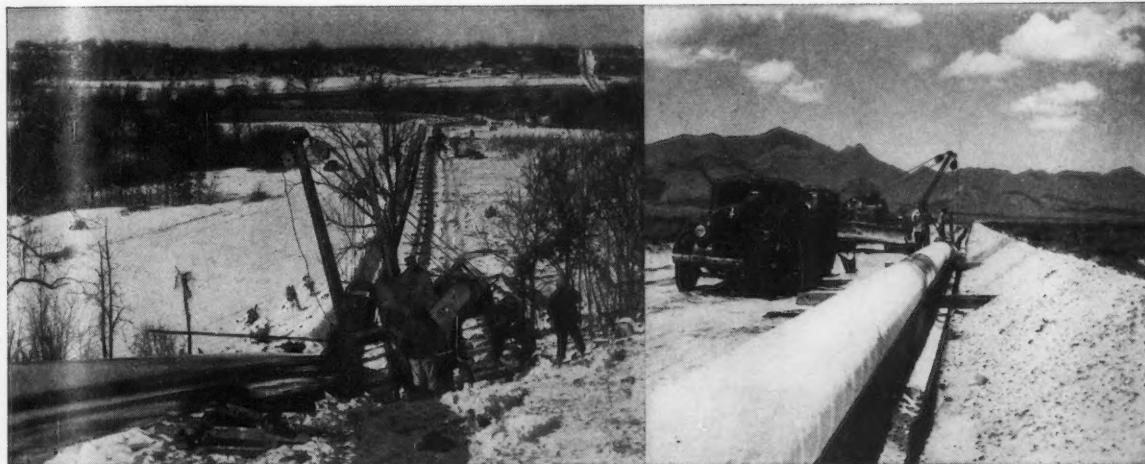
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LINGLE, ROBERT J., 319 Shell Bldg., Houston, Texas. (James E. Mavor Co., 514 M. & M. Bldg., Houston 2, Texas.)

PARKER, MARSHALL E., JR., 2023 Jean St., Houston, Texas. (Cathodic Protection Service, 4601 Stanford, Houston 6, Texas.)

PATRICK, GEORGE M., John D. Trilisch Co., 1310 McKinney Ave., Houston 2, Texas. (John D. Trilisch Co., 511 Petroleum Bldg., Houston, Texas.)

RILING, WILLIAM W., 5609 Washington Ave., Houston 7, Texas. (Standard Roofing Co., Inc., 4910 Navigation Blvd., Houston, Texas.)

SLINE, LOUIS L., Sline Industrial Painters, 1102 Taft, Houston, Texas. (Sline Co., Inc., 1102 Taft, Houston, Texas.)

SMITH, ALONZO L., Petroleum Instrument Co., P. O. Box 6252, Houston 6, Texas. 4012 Willowick Rd., Houston, Texas.)

STRUHEN, FREDERIK J., JR., Fish Constructors, Inc., M. & M. Bldg., Houston, Texas. (United Gas Corp., Box 2628, Houston, Texas.)

TRILSCH, JOHN D., John D. Trilisch Co., 1310 McKinney Ave., Houston 2, Texas. (John D. Trilisch Co., 826 M. & M. Bldg., Houston 2, Texas.)

VIRGINIA

ALEXANDER, ALLEN L., 1710 Oakcrest Dr., Alexandria, Virginia. (1300 You St., S. E., Washington 20, D. C.)

FOREIGN

HAGER, FREDERICK, Box 202, Elmira, Ontario, Canada. (Navgatuck Chemicals, Elmira, Ontario, Canada.)

THATCHER, FREDERICK G., JR., c/o Creole Petroleum Corp., Retineria, Caripito, Monagas, Venezuela. S. A. (Esso Standard Oil Co., Baton Rouge, Louisiana.)

NEW NACE CORPORATE MEMBERS

New Corporate Members added in the interval March 15-April 15, 1950, by the National Association of Corrosion Engineers:

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PENNSYLVANIA SALT MFG. CO.

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Philadelphia 7, Pa.

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THE PROCTOR & GAMBLE CO.

Engineering Division

M. A. & R. Bldg., Ivorydale

Cincinnati 17, Ohio

George F. Lockeman,
Representative

March in
New York

Corrosion Problems

Questions and answers for this heading should be submitted in duplicate if possible, addressed to "CORROSION PROBLEMS", National Association of Corrosion Engineers, 919 Milam Building, Houston 2, Texas. Questions received at the address above will be sent to E. A. Tice, The International Nickel Co., Inc., N. Y., who is acting editor of the page. All questions will become property of NACE. Questions and replies may or may not be published under this heading and may be answered either by mail directly to the person asking the information, or published under this heading, or both, at the discretion of the editorial staff. Answers to published questions are solicited. Authors of questions will remain anonymous to readers, while authors of answers may remain anonymous if they request it.

No. 31—At a fueling station for diesel locomotives, the fuel oil is piped from a 20,000 gallon storage tank through 1800 feet of 6" diam. steel pipe to the locomotive. Rust in this line breaks loose and is carried into the fuel tanks of the locomotive where it causes trouble by clogging filters. The oil remains in the line for an average of four to eight hours.

Is there a method which can be used to prevent corrosion in the 6" line, which will not have an adverse effect on the fuel?

If not, is there an economical material which can be used in place of steel for this pipe line?

ANSWER

Two types of paint systems have been suggested for the interior of the 6" line, both of which would involve removal of the line from service for paint application. Consequently it might be more feasible to replace the existing line with new pipe coated internally with one of the systems suggested:

- A. Baked phenol-formaldehyde thermosetting plastic, applied to a descaled surface.
- B. Vinyl resin base primer paint, plus two coats of a vinyl top coat, applied to a sandblasted surface.

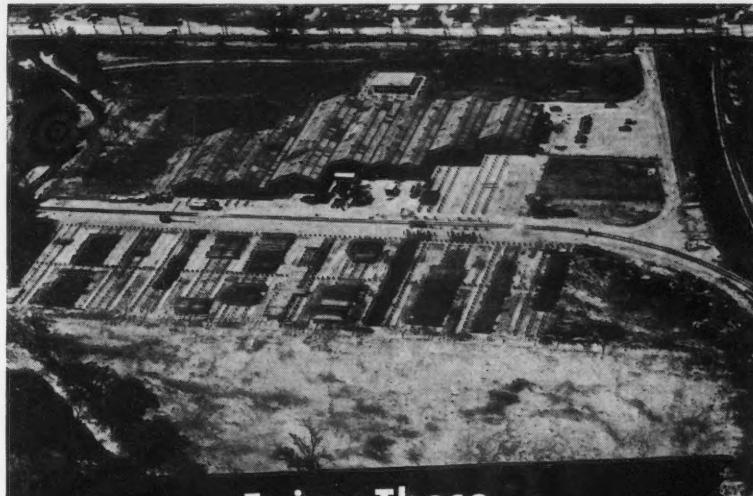
Since solid alloy pipe materials having satisfactory corrosion resistance are probably too costly, the possibility of employing an internally plated pipe, such as nickel plated pipe, might be considered. Its cost might be two to three times the cost of uncoated steel, but would certainly be less than that of solid pipe of a highly alloyed steel or nonferrous materials.

No. 32—We are endeavoring to find a paint system which will give a reasonable life (three months would be acceptable) on the interior of steel tanks in contact with a 12% caustic soda solution and chlorine fumes. The temperature in the tanks may vary between 180 and 250° F.

We have tried red oxide and zinc chromate primers and various types of top coats, such as a vinyl base paint, but these paints do not stand up for more than three weeks.

Is there a satisfactory paint system available which can be applied in the field?

In our repainting procedure the surface is cleaned with a paint re-



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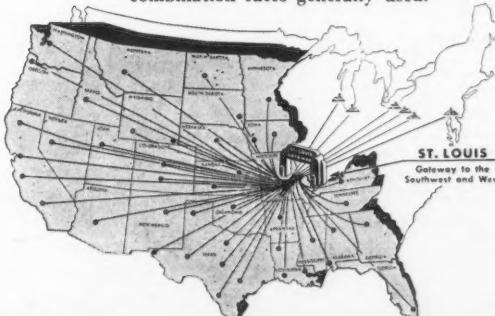
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CORROSION DIRECTORY

Rates for notices under this heading can be obtained from
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Systems . . . supplies . . . service
for special applications; water tanks
and pipe lines.

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Designed and Installed**
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Portable Units Available for Rail-Head
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CORROSION SURVEYS
Recommendations and supervision of
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Modern Portable Railhead
Equipment for Any Size Pipe or Job
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"The Complete Coating Service"

mov. During the 24 hours which elapses between cleaning and repainting, some corrosion of the steel occurs. Can a suggestion be offered as to a method of preventing this corrosion?

ANSWER

This appears to be a problem mainly of obtaining a clean surface for painting, although the service conditions are such that one is risking a lot from a paint system. The use of a phosphoric acid wash treatment, applied immediately after cleaning of the surface should be a help. If at all practicable, the steel surface should be sandblasted first to remove heavy rust. No coating can be expected to perform well over wet rusty surface.

Either a vinyl resin or a chlorinated resin paint system might then be applied, but neither should be considered to be a "cure-all" or "miracle" paint for the service involved.

No. 38—On a gasoline tank farm or terminal, where tank bottoms and underground pipe-lines are cathodically protected by means of rectifiers, what fire hazards exist during loading and unloading of transport trucks, tank cars, or tankers? Should rectifiers be turned off when loading or unloading? Should all lines to docks and loading racks be insulated from lines under protection?

ANSWER

The problem depends upon so many local factors that a direct yes or no answer should not be given to this question. In such a system the possibility exists for a lower resistance path from an anode bed to a tank ship or tank car than to the system under protection. Such a situation could cause serious trouble.

Because of the possibility of such complications it appears that the only safe thing to do would be to have a careful engineering survey made of each installation to determine the potential fire hazard. Lacking such a survey it appears that the next most logical thing would be to turn off the rectifiers when loading or unloading tank ships and tank cars.

Looking at this situation from an unbiased point of view, it appears that the use of galvanic anodes would eliminate these hazards.

**We Want Your Answers
To
Corrosion Problems**

Replies to questions under this heading are solicited by NACE. Tables, graphs and illustrations necessary for a full answer are welcomed. Address your answer to NACE Central Office, giving the question number. Early publication of answers is proposed.

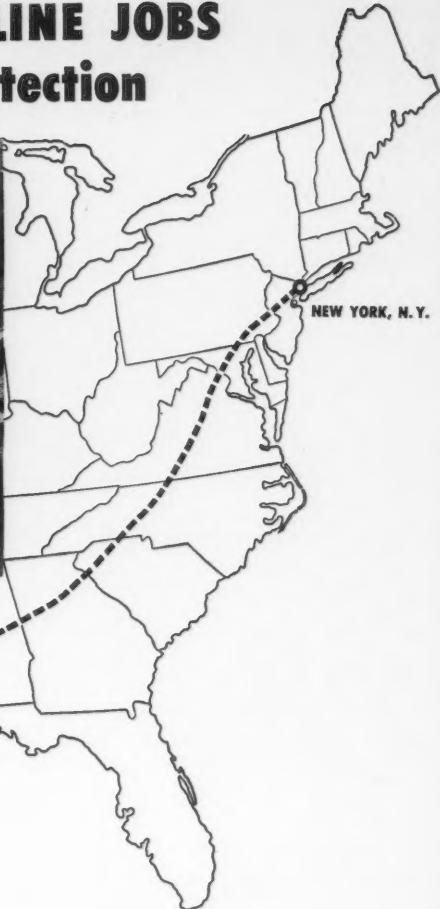
**MEMBERSHIP CARDS
AVAILABLE**

Association members in good standing will be issued on request a membership card in the National Association of Corrosion Engineers. Address requests to A. B. Campbell, Executive Secretary, 919 Milam Building, Houston 2, Texas.

ONE OF 1950's BIGGEST PIPE-LINE JOBS gets Bitumastic's lasting protection



Cleaning and priming of the huge Transcontinental line takes place at one of the hundreds of stream crossings along its 1,840-mile route. The complete line was designed and constructed by Fish Constructors, Inc., Houston, Texas.



By late Fall, the 1,840-mile line being laid by the Transcontinental Gas Pipe Line Corporation will be supplying natural gas to the Philadelphia—New York—New Jersey area.

And, like many of the country's other big pipe-line projects, it will be protected against corrosion by Koppers Bitumastic® Enamel for many miles of its length. Por-

tions of the 30-inch line which Bitumastic will protect include some of the most highly corrosive soils encountered—low, swampy land along the Gulf Coast.

Bitumastic Enamel has been used for over 25 years in coating thousands of miles of gas and oil lines. The knowledge gained by Koppers from the experience on these many successful applications

can prove to be of value on your next pipe-line job.

Put "Koppers Bitumastic Enamel" into the specifications of your next job. You'll be getting a coating that has proved itself by years of satisfactory service under the most extreme corrosive conditions . . . in all types of soil . . . under variations of temperature.

Why Bitumastic Enamels give lasting protection

Processed from a base of coal-tar pitch, they are impervious to moisture . . . chemically resistant to soil elements. They make a tight bond with the pipe . . . do not disintegrate with age . . . maintain continuously high electrical resistance.



BITUMASTIC ENAMELS
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KOPPERS COMPANY, INC., Tar Products Division, Dept. 504T, Pittsburgh 19, Pa.

NEW PRODUCTS—Materials—Service—Literature

Chemical Electric motors designed for use in environments where corrosive fumes or liquids are encountered are available from Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa. CSP "Life-Line" motors have exposed parts alkali cleaned, rinsed in chromic acid spray, and are coated with baked phenolic-alkyd-type enamel, plus a coat of gray enamel and two to four baked dips of thermoset varnish, followed by a final gray lacquer coat.

Blowers are bronze, split-hub, clamp

type with rotating neoprene slingers on shafts between rear brackets and hoods. Stator windings are double-dipped and baked in thermoset varnish.

Corrosion Resistance of Hastelloy alloys to six common corrosive media are listed in easy-to-read tables in the new edition of the 40-page booklet "Hastelloy High-Strength, Nickel-Base, Corrosion Resistant Alloys," which is available to designers, engineers and fabricators faced with the problem of selecting a

high-strength material that will withstand severe chemical corrosion. Copies may be secured by writing to Haynes-Stellite Division, Union Carbide and Carbon Corp., Kokomo, Ind. Tables of properties and graphs comparing the alloys to four other commonly used construction materials are included. Procedures for welding, heat-treating, hot-working and cold-working of the materials are given. The alloys are particularly recommended by the manufacturers for equipment that must handle hydrochloric and sulfuric acids, free chlorine, aqueous solutions containing chlorine or hypochlorites, acid solutions of ferric or cuprous salts and brine or salt spray.

Waterproofing for outside masonry walls above grade is possible through use of improved No. V transparent coatings, according to Ranetite Manufacturing Co., Inc., 1917 South Broadway, St. Louis 4, Mo.

Printers' Spacing material, chases and press and machinery parts now are being fabricated from magnesium by Hills-McCanna Company, Chicago, Ill.

Teaching Safety with comic books is a new venture by Ebasco Services Incorporated to tell the story of utility safety work to mass audiences. The first of a series of books is called "Danger Flies a Kite." Subsequent issues will deal with other aspects of the utility industry. W. T. Rogers, Ebasco safety consultant is in charge of the program.

Bjorksten Laboratories has established a New York City office at 50 East 41st St.

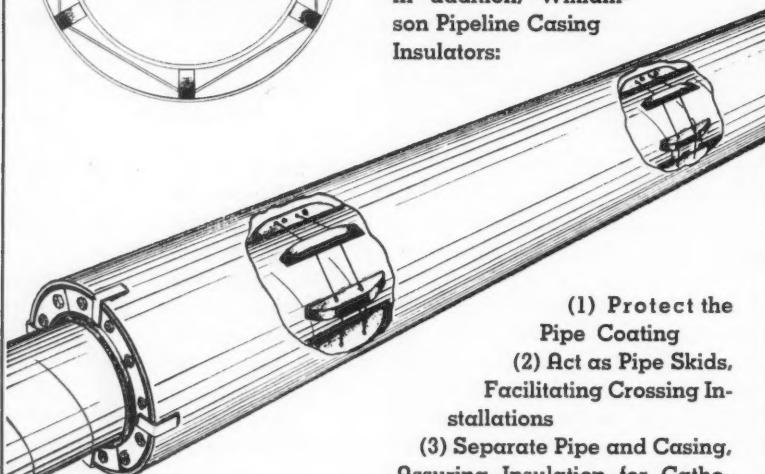
Precision Potential measurements of any type where a laboratory potentiometer is required are possible with the new Model P-2 Precision Electronic Potentiometer made by Southwest Industrial Electronic Co., 2831 Post Oak Road, Houston 19, Texas. The instrument, with self-contained 100-hour batteries is recommended by manufacturers for making precise potential measurements on high-impedance electrochemical cells or electronic tubes and circuits. It is suitable for measurement of potentials from zero to 3 volts in three ranges. Current flow in the measured circuit is less than 10^{-11} amperes. Accuracy is plus or minus one millivolt plus 0.1 percent.

Additional Space for South Florida Test Service, 4201 N. W. 7th Street, Miami 34, Florida, and the erection of a new laboratory are announced by the company for expansion of its inland proving grounds. Added space will comprise a city block. South Florida Test Service specializes in weathering, corrosion and sunlight tests using southeastern Florida's subtropical weather conditions. All kinds of products and materials are tested by the firm for durability and permanency by actual exposure to atmospheric and sunlight attack direct and under glass. The firm maintains a complete weather station and solar radia-

WILLIAMSON "CONCENTRIC SUPPORT" PIPE LINE CASING INSULATOR*



This improved Williamson Pipeline Casing Insulator approximately centers the line pipe in the casing. This removes support of pipe from "WmSEAL" Casing Bushings, and facilitates their installation. In addition, Williamson Pipeline Casing Insulators:



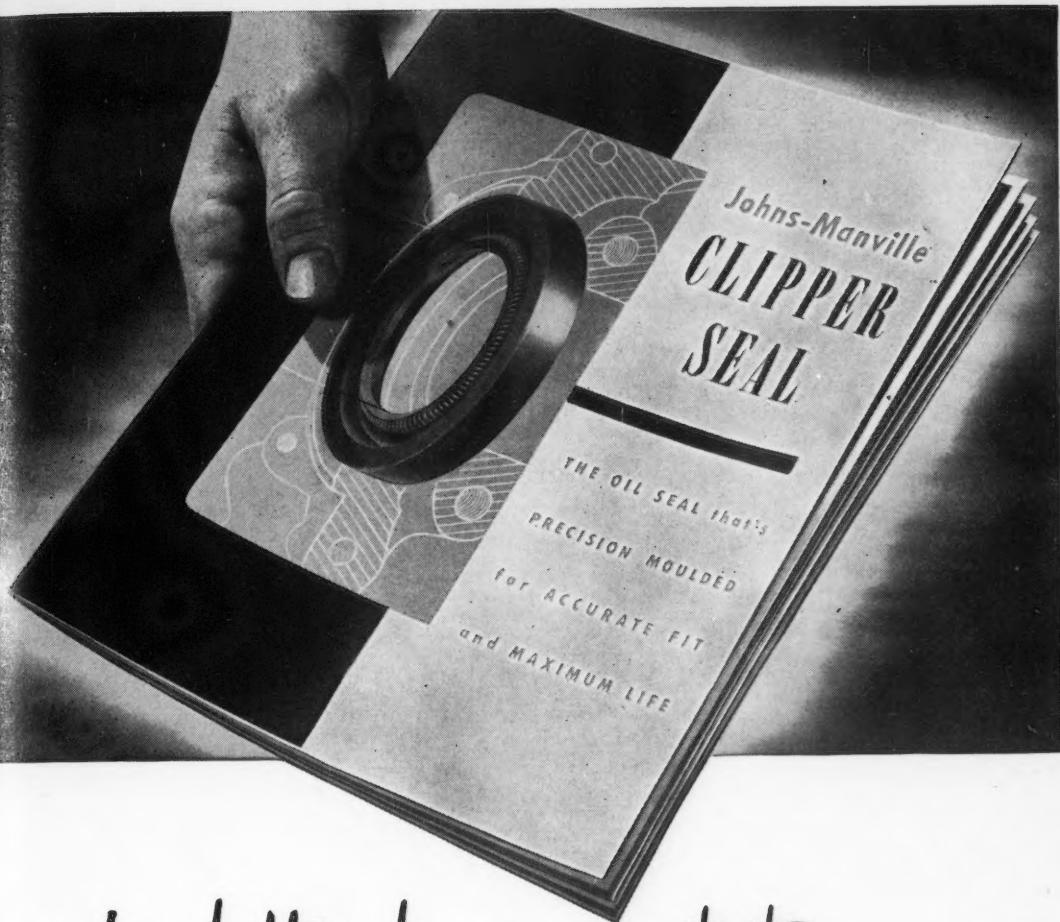
- (1) Protect the Pipe Coating
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*Patents Pending



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tion recording instrumentation at its inland proving grounds.

It now maintains three South Florida testing locations in addition to the main inland field test and laboratory in Miami. These locations at Miami Beach are for salt atmospheric tests and tidewater and total marine immersion. A warehouse for storage tests on packaging of foods

and metal parts also is maintained at Miami.

Mutual Boiler Insurance Company of Boston has changed its name to Mutual Boiler and Machinery Insurance Company. Two new boiler and pressure vessel inspection territories, one at Altoona, Pa., and the other at Houston, Texas, have been opened.

Cathodic Protection of steel water tanks is described in a folder offered by Cathodic Rustproofing Company, Carrizo Springs, Texas. The folder describes briefly the electrical method of protection, practical types of electrodes, wiring and service. Copies of this folder and recommended specifications for cathodic protection of steel water tanks are available on request.

Grebe & Doremus Process Company has moved to its new location at 4601 Stanford, Houston 6, Texas.

Corrosion Resistant castings are described in its Bulletin No. FC-350 by the Ohio Steel Foundry Co., Lima, Ohio. The bulletin, titled "Fahrite Corrosion Resistant Castings," shows photographs of some of the types of forms cast in stainless steel and lists Ohio Grade Numbers in tabulation with ACI types and AISI types, with chemical range in percentages. Copies are available on request.

A Thermo-Setting Resin "Duron" is said by Electro Chemical Supply & Engineering Co., 750 Broad St., Emmaus, Pa., to be useful as an acid and alkali resistant cement or coating, and to adhere without use of a primer to concrete or metal. It is self-hardening at room temperature. Adhesive qualities of the material are attributed to the fact it is not derived from phenolic or furfuryl alcohol resins. It may be used also in combination with metal powders, asbestos, cork and other insulating materials.

Teflon Rods and tubing now are being manufactured by The Polymer Corp., Reading, Pa.

New Rust-Preventive for aircraft engines, "Rust-Ban 626" has been developed by the Humble Oil and Refining Company, according to a story in January-February, 1950, issue of "The Humble Way," external house organ of the firm. The product also may be obtained as "Rust-Ban 623" for all internal combustion engines. The materials are additives to lubricating oils in the proportion of one part of concentrate to three parts oil. The oil, used for preservation of the engines in storage, then distributes the preventive over surfaces to be protected. The material, not specifically described in the article, is said to form ash or undesirable deposits when engines are started up.

Cutting Costs in pickling operations are described in a booklet "5-Way Savings in Pickling," issued by The International Nickel Co., Inc., available without charge from the Pickling Section of the company, 67 Wall Street, New York 5, New York. The booklet illustrates various kinds of Monel pickling equipment and itemizes advantages over other equipment used for similar purposes. Several shapes and sizes of Monel gas welded chain are shown.

Plastic-Base Coatings designed for specific corrosion service have been developed by Specialty Coatings Laboratory, 1721 North Water Street, Milwaukee 2, Wis. The V-200 Series is recommended for use for protection from strong corrosive fumes. They are available in clear or colors and may be applied by conventional methods. They air-dry or may be baked to provide a flexible, abrasion resistant coating. Corrosion-inhibiting pigments are incorporated to provide long time protection when subjected to salt atmospheres, alcohols, soaps, fruit juices, acids, alkalies, petroleum products or related corrosives.

Liquid and Gas valve sizing charts are available from Fisher & Porter Company, Hatboro, Pa., Department 7007. The chart takes into account the difference between pressure drop across the valve and across the valve ports alone, liquid viscosity and specific gravity in determining port area and valve size as well as inlet and outlet absolute pressures, gas specific gravity and temperature.

Quick Dry Clear Vinyl coatings designed for use on concrete floor systems are available from Wilbur & Williams Co., Greenleaf & Leon St., Boston 15, Mass.

Painting With Aluminum, a 32-page brochure for industrial users of aluminum paint is available from Aluminum Co. of America, 661 Gulf Building, Pittsburgh 19, Pa. The brochure, which contains 30 photographs, lists paints in three classifications: for metal, concrete and masonry and similar non-absorbent surfaces, for weather-exposed wood and for interior heated surfaces and for decorative uses. An aluminum paint coverage table is given.

Polyken Electrical Tape is claimed by Bauer & Black, manufacturers, to exceed ASTM friction tape specifications in

anti-corrosive
strapping and seals

Send for free booklet and Strap Calculator containing information as to suitable type of metal to be used.

Describes A. J. Gerrard special strapping and tools.

STEELBINDER
Steel Strap CALCULATOR

FREE
Handy calculator—one side tells you which strap to use for any given corrosive condition; the other side determines length and weight of strap required for any binding operation. SMC

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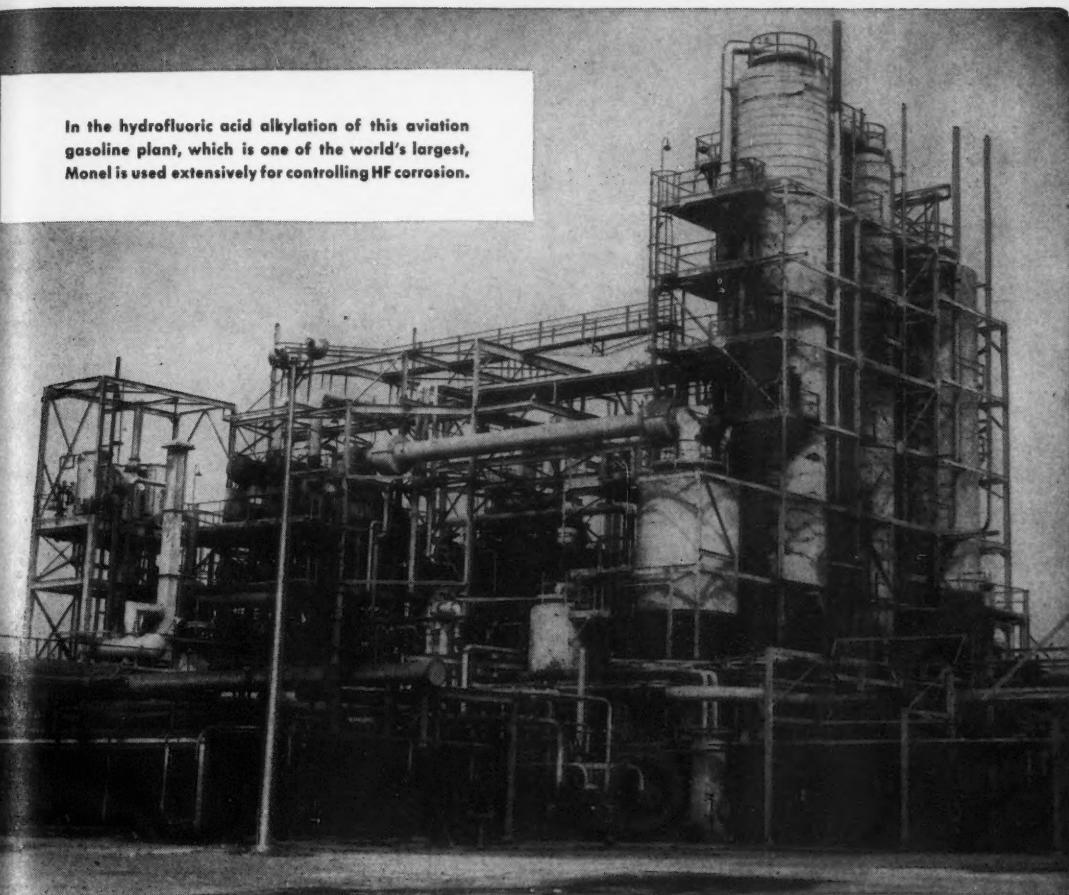
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dielectric strength, moisture impermeability, to have less bulk with equal strength, be quicker sticking, cleaner, easy unwinding, have high fay resistance and firm adhesion to any clean surface. A free descriptive folder on Polyken No. 163 Electrical Tape "Test It Yourself" is available on request from Polyken Industrial Tape, 222 W. Adams St., Chicago 6, Ill.

Uses for Glycerine in foods, drugs and cosmetics, alkyl resins and ester gums and textiles and a general survey of all other glycerine uses are detailed in five booklets by Glycerine Producers' Association, Dept. PR, 295 Madison Ave., New York City 17. Copies are available on request. The booklets contain tables on specific gravity, viscosity, freezing point and other characteristics of aqueous solutions at various concentrations and a bibliography of references.

Metallizing Applications made by Metallizing Engineering Co., Inc., 38-14 Thirtieth St., Long Island City 1, New York, are reported in Metco News, issued by the firm. Copies are available on request. The current issue relates metallizing work on eroded turbine components.

Rubber Coated Hoods, resistant to most acids, moisture, caustics, oils, solvents are produced by General Scientific Equipment Co., 2700 W. Huntingdon St., Philadelphia 32, Pa., for use in occupations where splash hazards exist. There is a large plastic window and supporting frame inside. It may be worn with goggles or respirator.

Free-Machining Welded stainless steel tubing with an analysis of carbon .08 percent max., chrome 17-19 percent; nickel 8-10 percent and selenium .07 percent min. has been developed by The Carpenter Steel Company, Alloy Tube Division, Union, N. J. It is designated Type 303.

United Chromium, Inc., has moved its Detroit office to 1700 E. Nine Mile Road, Ferndale Sta., Detroit 20, Mich. Besides sales offices, five fully equipped laboratories have been provided for simultaneous research in the numerous expanded activities of the firm. The firm's organic coating laboratories are at Carteret, N. J.

Floating Roofs, including the double-deck, pontoon and pan types manufactured by Chicago Bridge & Iron Co., 332 South Michigan Ave., Chicago, Ill., are illustrated and diagrammed in Bulletin B titled "Horton Floating Roofs," available on request from the manufacturers.

Stainless Steel Bellows pumps for laboratory scale pumping of materials are offered by Research Appliance Co., Box 413, West View Road, Pittsburgh 9, Pa. Rates of flow: $\frac{1}{2}$ -inch bellows 15-1000 ml/hr; $\frac{3}{4}$ -inch bellows 30-2000 ml/hr. The pump weighs 5.6 lb, has $\frac{1}{2}$ -inch connections, a 110 v 60-cycle 30 rpm motor, toggle switch and has no packing gland or stuffing box. All connections are machined fits requiring no compounds or gaskets.

Polyethylene-Lined Hackney open head seamless 30 and 50-gallon barrels are now offered by Schori Process Division of Ferro-Co Corp., 8-11 Forty-Third

Road, Long Island City 1, N. Y. The drums are designed for acid transport as a substitute for crocks and glass vessels which are subject to damage in transit. The drums may be re-used, the company says. Polyethylene coatings 1/32-inch and $\frac{1}{8}$ -inch thick are used.

Fisher & Porter Co., Hatboro, Pa., will hold its third quarterly instrumentation course July 10-14.

OBITUARY

Harley Arthur Nelson, of The New Jersey Zinc Company (of Pa.), Palmerston, Pa., died March 21. He was author or co-author of almost 50 papers and publications dealing with pigments, organic protective coatings, paint testing, corrosion and related subjects. He was born August 1, 1890, at Herington, Kansas, was employed by the National Bureau of Standards, Washington, D. C. in investigation of Corrosion and anti-freeze mixtures for aircraft radiators, joining the research division of The New Jersey Zinc Co. in 1919. He was a member of numerous technical societies and organizations.

He is known for his work on paint testing and especially for the development of accelerated weathering apparatus and techniques.

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Corrosion Abstracts

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TESTING

• Laboratory Methods

2.3, 6.3

Glass Corrosion Tests on Refractories. A. C. Siefert, J. J. Webber, Owens-Corning Fiberglas Corp. and F. V. Tooley, Univ. of Ill. Paper before Amer. Ceramic Soc., 51st Ann. Mtg., Cincinnati, April 24-28, 1949. *Ind. Heat.*, 16, No. 9, 1632 (1949) Sept.

Tests developed to provide data for predicting service life of glass tank blocks consists of a crucible test (carried out in a Pt crucible), a crucible flow test, a simulative service test and a production furnace test.—INCO.

2.3, 2.1, 4.2

Twenty-Five Years of Paint Testing. M. van Loo. *Ind. and Eng. Chem.*, 41, No. 2, 267-71 (1949) Feb.

A review of the contributions made by improved testing techniques to recent advances in the paint industry, with special reference to exterior house paints. Some shortcomings in accelerated laboratory tests are critically discussed, and field test methods are described, with notes on the construction and design of exposure test panels. The effects of climatic differences on performance are also dealt with. There is a bibliography of 19 references to the literature.—ZDA.

• Instrumentation

2.4, 2.2

Immersed Ultrasonic Inspection. R. H. Smith and D. C. Erdman. *Iron Age*, 164, No. 5, 83-88 (1949) Aug. 4.

A newly developed method of inspection for internal defects—ultrasonic inspection—is described. Two testing methods are open to the ultrasonic inspector, contact scanning and immersed scanning, both of which involve an understanding of the path taken by the sound wave in traveling from the crystal to the part. Immersed inspection requires more time per part than contact inspection and a considerably better-trained operator. The test-set requirements are more stringent and hence the set costs more. Under present conditions it takes an average of 10 hr. to completely inspect a large turbine rotor. It is not generally recognized that ultrasonic inspection is one of the few inspection methods that give defect information in terms of electric signals; hence it is subject to easy adaption to automatic inspection.—TDD.

2.4

Inspection by Optical Projection. A. E. Williams. *Mech. World*, 124, No. 322, 407-411+ (1948).

W. describes the various optical-projection methods available for the dimensional inspection of machined parts.—MA.

2.4, 3.2

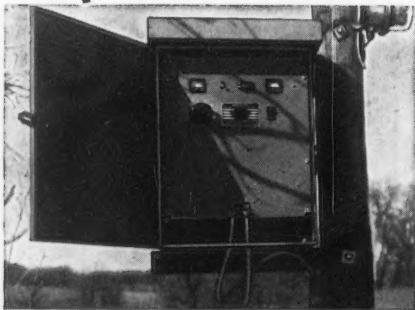
The Detection of Cracks by X-rays and Gamma Rays. C. Croxson, Gt. Brit. Ministry of Supply, Aramont Research Dept. *Electronic Eng.*, 20, 106-111 (1948) April.

The radiological method of crack detection can be considered sound and reliable with few limitations. Hot tears and cracks in castings and, with good techniques, also in forgings are certain to be detected. Small cracks in welds may possibly escape detection, but these are of little practical significance. Gamma rays can be used advantageously to give a general picture in positions which are inaccessible to X-ray apparatus; however, they are not always an efficient and simple substitute for X-rays. Further research on radiographic technique is necessary to find how the discernibility of cracks varies in materials of different thicknesses and densities.

The radiological method is not affected by looseness of structure in metallic castings or by inhomogeneities in the material. It can be used to investigate cracks and crack-like defects on the surface and to detect them in the interior of both magnetic and nonmagnetic metals and alloys ranging from a few hundredths of an inch in welds, to those several inches thick in steel and other materials. The most common applications are probably to steel castings and welds 0.5—2 in. thick.

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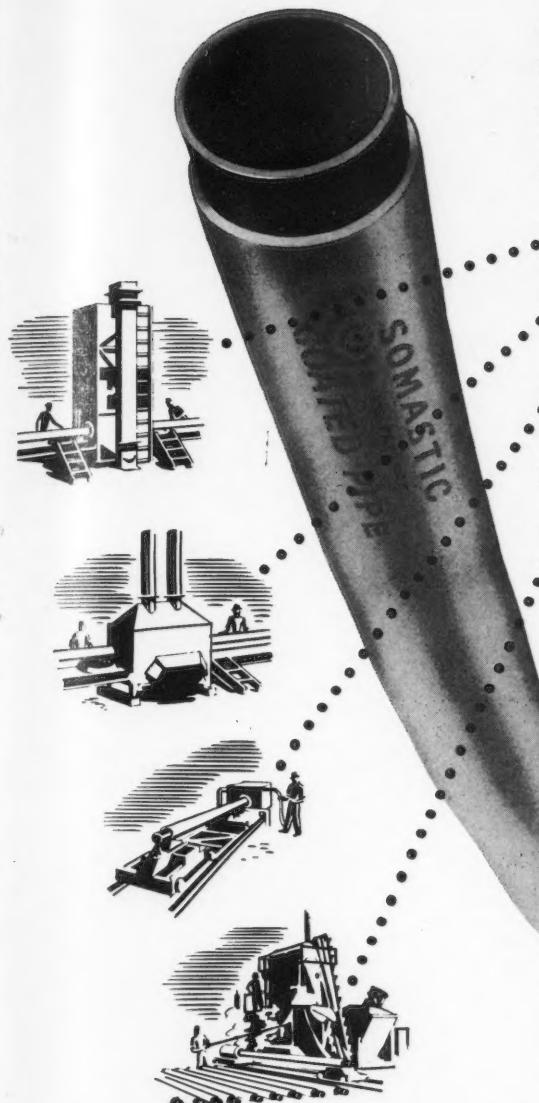
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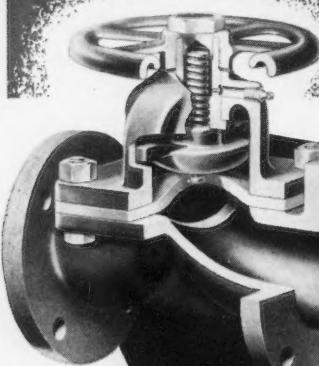
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2.4, 6.1

Method of Investigating Metals by Means of Permeability Meters with Demountable Coils. I. Epelboin, A. Marais and P. Pannetier. *Rev. Met.*, 46, No. 5, 315-318 (1949) May. (In French.)

Account of an instrument for testing various ferromagnetic core materials, in which the specimen forms the core of an inductance coil.—BNF.

2.4

Non-Destructive Testing of Materials S. Forster. *Werkstatt u. Betrieb*, 81, No. 3, 71-74; No. 4, 103-104 (1948).

A review of X-ray and gamma ray radiography, magnetic testing, and ultrasonic testing.

2.4, 5.2

Characteristics of Half-Cells Used as Reference Electrodes. P. Fugassi. Cathodic Protection Symposium (Electrochemical Society and National Association of Corrosion Engineers), 1947 (published 1949), pp. 34-36.

Discusses various reference electrodes for use in making emf measurements including those involved in cathodic protection methods.—BNF.

2.4, 5.8, 2.6

Pulse Polarizer in Corrosion Technology. H. J. McDonald & G. A. Marsh. Paper before NACE, 5th Ann. Conf., Cincinnati, Apr. 11-14, 1949. *Corrosion*, 5, No. 8, 254-260 (1949) Aug.

Application of pulse polarizer to study of polarizing and de-polarizing characteristics of metals and solutions is reviewed. Influence of current density, temperature, pH of solution, inhibitors and electrode material on polarization curves are discussed. Correlations indicate that small polarization curves are given by systems having a rapid spontaneous reaction rate. Applications of instrument to study of corrosion inhibitors, to choice of a metal for use in a particular environment to alloy identification and to choice of an inhibitor for stress corrosion are described. For some corrosion reactions under cathodic control, data obtained with pulse polarizer may be used to predict corrosion rates in a quantitative fashion and it was found that energy of activation for dissolution of iron in acid, calculated from polarization data, is of same order of magnitude as energy calculated in conventional way. Other applications of pulse polarizer are given. 15 references.—MA.

2.4, 2.3, 5.4

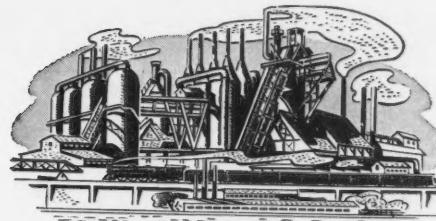
Testing the Corrosion-Resistance of Non-Conducting Lacquer Films on Preserving Cans. K. Melnert. *Arch. Metallurg.*, 2, No. 4, 140-144 (1948).

A method is described, based on resistance measurements on an A.C. bridge, for determining the porosity of lacquer coatings and for studying the progress of corrosion.—MA.

2.4, 3.7

Magnetic and Electrocal Methods of Non-Destructive Testing. P. Michel. *Rev. Gen. Elect.*, 58, No. 3, 91-103 (1949).

M. discusses the relations between the



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mechanical and magnetic characteristics of materials and outlines the development of magnetic testing methods. Magnetic-particle testing methods are described and suggestions made for testing techniques for articles of complex shapes. Fluorescent inspection and fluorescent magnetic inspection are briefly mentioned. Among the electromagnetic tests reviewed are those employed for flaw detection, metal sorting, and detection of heat-treatment condition. Short notes are presented on resistance tests, and tribo-electric and thermo-electric techniques.—MA.

2.4. 5.4

Ultramodern Supersonics and X-Rays. J. J. Pierce. *Met. Prog.*, 56, No. 1, 62-65 (1949) July.

Brief account of equipment for non-

destructive testing at the U. S. Naval Ordnance Laboratory, including a 10MV. mobile betatron used as a source of X-rays, and a new Magnaflux Corp. particle instrument for testing vitreous enamels, etc. for cracks. Also reports of conference on non-destructive testing.—BNF.

PREVENTIVE MEASURES

• General

5.1

Insulation of Pipe Fittings with Plastics. J. A. Clay, Jr. *World Oil*, 128, No. 13, 157-8, 160 (1949) Apr.

Well tubing, casing and other oil field pipe corrosion resulting from the combined effects of chemical corrosion and

stray currents may be two to ten times as great as that caused by either. Laminated plastics have been used as electric insulators for more than 30 years and should be suitable for insulating oil field equipment if their mechanical strength, alkali, acid, organic solvent, light, heat and gas pressure resistance are adequate. A laminated, phenolic resin, fabric base plastic has been the most satisfactory material used in stopping stray currents in oil field piping. Field tests indicate that the tensile strength of a plastic nipple is sufficient for ordinary use but not for eccentric or side loading. The requirements and design of plastic ring and flat flange gaskets, bolt sleeves and washers are discussed. To prevent external current by-passing, the pipe should be coated or raised above the ground for a distance of at least 50 pipe diameters on each side of the fitting. Flanges should be wrapped and coated to prevent bridging between the flange faces. Methods for checking the efficiency of the insulation are discussed.

5.1

Electrochemical Studies on Insulating Couplings for Underground Pipe and Cable Lines. W. Beck. *Corrosion*, 5, No. 6, 175-181 (1949) June.

Investigation of electrochemical factors which enable an insulating connection to protect an underground pipe or cable section against stray-current corrosion; examination of relations between (a) resistance of coupling, and (b) time, and corrosive conditions; determination of stray-current density near couplings in an electrolyte after application of a polarizing EMF.—BNF.

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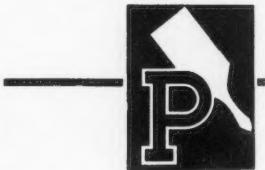
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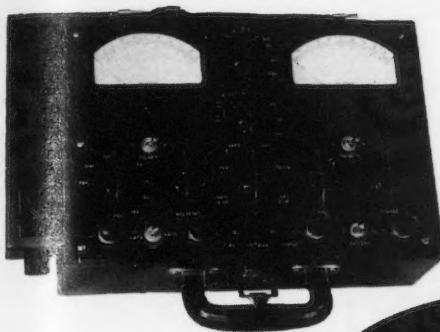
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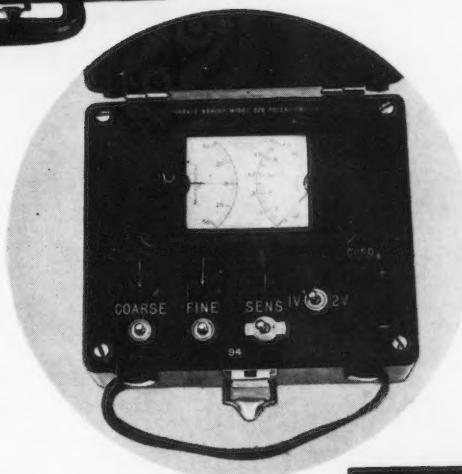
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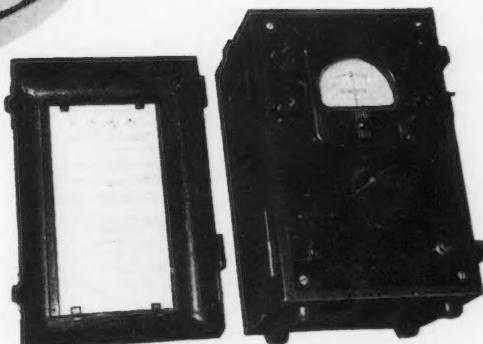
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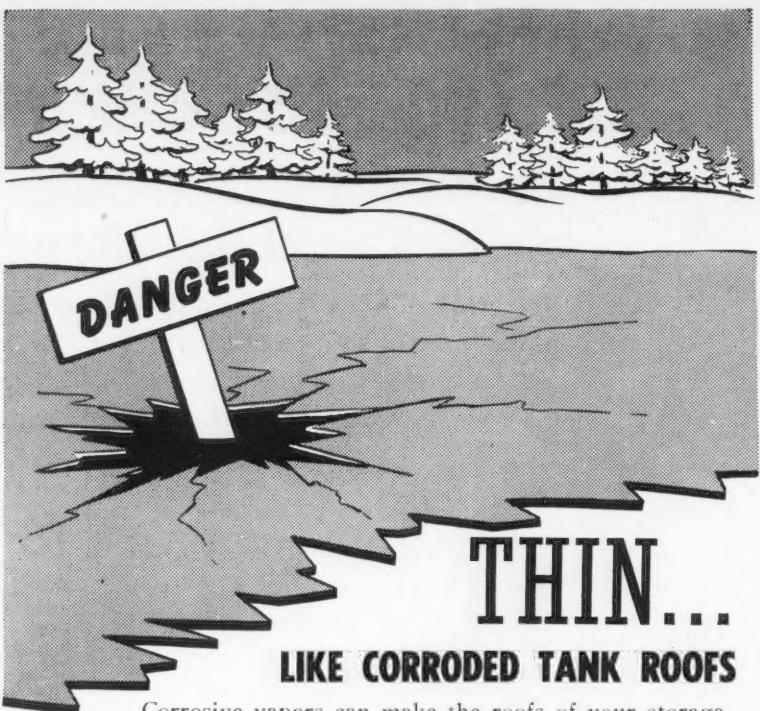
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• Cathodic Protection

5.2

Cathodic Protection of Galvanized Hot Water Storage Tanks by Use of Galvanic Magnesium Alloy Anodes. D. J. Fergus. Educational Bull. EB-104. Apr. 1st, 1949. Cleveland Heater Co., 2310 Superior Ave., Cleveland 14, Ohio 16 pp.

An account of tests made with domestic water supplies, with particular reference to Cleveland softened tap-water. It was shown that magnesium anodes could be very successful in protecting galvanized hot water tanks. Measurements on the current between the two electrodes (zinc coating and magnesium) were also made to determine the best position and size of anodes required to give efficient protection. The composition of the anodes was also studied so that changes could be made in polarization characteristics.—ZDA.

5.2

Magnesium Anodes Extend Water Heater-Tank Life. T. D. Fullford. *Electric Light and Power (England)*, 26, 788 (1948). *Chem. Absts.*, 43, 1306 (1948) Feb. 25.

Lab and field tests indicate that a magnesium anode will completely stop or markedly reduce corrosion. Tests are described and results tabulated and charted. Even at highest current flow the amount of Mg^{+2} introduced does not exceed 5 ppm, and does not effect water rotability.—ALL.

5.2

Magnesium Cathodic Protection to Inhibit Corrosion of Bronze Facing Wires on Grounding Deckers. R. D. Duncan. *Pulp and Paper Mag. (Canada)*, 50, No. 3, 187-191, 1949. *Chem. Absts.*, 43, No. 10, 4012 (1949) May 25. ALL.

5.2

Cathodic Protection of Steel Water Tanks. P. E. Pallo. *J. AWWA*, 40, No. 7, 701-711 (1949). *J. Inst. Metals Mtg. Abs.*, 16, Pt. 9, 561 (1949) May.

In an investigation to determine degree of protection obtained in bare steel tanks an aluminum anode with an applied external potential was found to prevent corrosion of a bare steel surface; a galvanic magnesium anode inhibited corrosion of a bare steel surface despite an initial aggressive attack, but an electrode-less circuit with an applied external potential showed no protection against corrosion.—INCO.

5.2

Rustnode. *Oil Gas J.*, 48, No. 11, 105 (1949) July 21.

A new magnesium anode that offers cathodic protection against rust scaling on condenser heads, dividers, and tube sheets, Rustnode is designed to supplement water treating for most economical protective results, but in some cases may be used as only practical means of corrosion prevention in condenser heads. New anode, designed to protect only the walls of chamber within which it is placed, may be used within both fixed and floating heads. A plastic shielded mount allows all of current flow to be directed to useful protection, with little loss due to overprotection of immediate surfaces.—INCO.

Metallic Coatings

5.3 **Protective Coatings for Corrosion Prevention.** R. M. Burns. *Paint Var. Prod. Manuf.*, 29, No. 2, 58 (1949).

The processes of corrosion of metals are described and the role of protective coatings in corrosion control outlined. Recent developments in metallic and organic coatings are discussed, methods of quality control mentioned, and future trends in corrosion prevention predicted.—RPI.

5.3 **Report on Investigation of Methods of Gaseous Metal Treatment.** R. Hunter, P. H. Lawrence and R. L. Samuel. BIOS Final Report No. 1535, 1947, 14 pp.

Diffusion processes developed for surface impregnation of ferrous articles with either aluminum or silicon to increase resistance to oxidation at elevated temperatures and silicon to enhance resistance to corrosion and wear. Basis of experiments was Ihrig's process. 18-8 was treated to increase its resistance to furnace gases containing sulfur. Cast iron did not respond to the process, details of which are given. Protection imparted to the articles by aluminizing is satisfactory up to 950°C. Siliconizing is limited to small articles which are exposed to weak corrosion influences. Boron diffusion is mentioned briefly.—INCO.

5.3 **Tin Undercoatings.** S. C. Britton. *Paint Manuf.*, 19, No. 3, 95-96 (1949).

Besides the use of lacquered tin coatings in containers for foodstuffs a thin coating of tin 0.00005 in. thick has been shown to be very valuable under a great variety of paints exposed to various types of atmosphere. The results have usually been better than those produced by phosphating steel before painting. Under anti-corrosive and anti-fouling paints in sea-water immersion, tin undercoatings reduce considerably the spread of rust and the blistering and general deterioration of the paint coating, though there is a risk of galvanic action at scratches, etc., in the tin coating, leading to rapid pitting. The tin coat can be applied by hot-dipping, electro-deposition, spraying, or immersion, though the latter method gives a less satisfactory coating than the others. Local application of tin by wiping can also be used. The best keying of paint is obtained with the mat electro-deposited coatings, but even these do not give the adhesion that is obtained with phosphate treatment.—MA.

5.3 **Chemical Stability of Tin Coatings.** N. N. Gratsiansky and P. F. Kalynzina. *Zhur. Priklad. Khim.*, 21, 341-346 (1948) (In Russian). *Plating*, 36, 75 (1949).

Physical and chemical characteristics of electroplated coatings from various baths, especially stannate and sulphate, were studied. Factors influencing their chemical stability are indicated.—MA.

5.3 **The Tinning of Sheets with High-Frequency Heating.** G. H. Egri. *Elekt. Uerwelt*, Schweiz., 21, 250-251 (1947) Feb.-Mar. *Bull. Analyt. (CNRS)*, 9, No. 9 (1947) (1948).

A description is given of a process started in the U.S.A. in 1942 which effects an economy in the consumption of tin and considerably increases the production of tinplate. Notes are given on the H.F. generators used.—MA.

5.3 **Substitutes for Tin Coatings on Copper Wire.** Battelle Memorial Institute, Columbus, O. Final report; U. S. Signal Laboratory, Fort Monmouth, N. J., Contract No. W36-039-sc32263.

This summary report on the development of substitutes for tin coatings on copper wire is divided into three divisions based on types of coatings: hot dip, electrodeposited, and nonmetallic. Basic requirements of an acceptable substitute include good soldering properties, resistance to high humidity, and satisfactory functioning over a range of —55 to 200°C.

Hot-dip Alloy Coatings

In the soft-soldering temperature range, lead-base alloys are the most practical substitute for tin to obtain high solderability and corrosion resistance, both properties being greatly improved by additions of tin up to 15%. A lead-base alloy containing 15% tin, 0.5% silver, and 0.5% antimony is satisfactory on the basis of solderability and resistance to corrosion and sulfur tarnish. A 10% tin, 1% zinc alloy has satisfactory solderability, but only about one-fourth the corrosion resistance of the higher tin formulation. A tin-free lead alloy containing 4% silver and 1% zinc has good solderability but only about one-seventh the corrosion resistance of the coating containing 15% tin. About the same order of resistance is shown by a lead alloy with 5% tin, 1% cadmium, and 1% zinc. Coating thicknesses of 6×10^{-3} to 7×10^{-3} in. are most satisfactory.

Electrodeposited Metal and Alloy Coatings

Tin-free coatings having satisfactory adhesion, continuity, equal or better initial solderability than pure tin, and better retention of this last property under certain conditions of aging were prepared by electrodeposition. However, none of these tin-free compositions possess as good resistance to sulfur and high humidity as pure tin. The incorporation of small amounts of tin greatly improves these resistance properties. Several promising compositions are tabulated according to tin content, from which selections may be made according to the requirements of specific applications.

The best tin-free alloy is a eutectic mixture of 12% antimony and 88% lead. Its solderability is slightly less than that of tin, but it does not diffuse as readily into copper at high service temperatures. Its sulfur and corrosion resistance is poor. When it is plated with about 5×10^{-3} in. of pure tin the duplex coating has the same degree of solderability as a 6×10^{-3} in. pure tin coating on copper wire. Duplex coatings of tin over iron and tin over lead have about 75% of the solderability of tin over copper and pass the sulfur resistance test. Tin over iron has fairly good corrosion resistance at 105°F and high humidity.

Lead-tin alloys on cadmium underlay and several silver-alloy coatings possess good solderability but their poor resistance to sulfur tarnish in rubber results in lowered solderability. The lead-tin alloy overlay on cadmium has the disadvantage of a very low melting point. Continuity and adhesion were tested

by ASTM methods, sulfur resistance by vulcanization in normal and high-sulfur rubbers, aging by storage in helium at elevated temperatures, corrosion resistance by storage in air at high humidity at 105°F, and solderability by a modified Bell Telephone method measuring the capillary rise of molten solder up a twisted pair of wires.

Nonmetallic Coatings

A considerable number of organic films were developed which withstood temperatures up to 200°C. These films are continuous and flexible, and may be soldered easily without the use of a fluxing compound. When vulcanized in high-sulfur rubber, they char and lose adhesion to the wire. Their performance at subzero temperatures was not investigated.

Among the most satisfactory compositions are (1) a 5% VMCH solution (vinyl chloride-vinyl acetate), (2) a mixture of VMCH and Rezyl 330-5, an alkyd resin, (3) a 4% mixture of Geon 202 (plasticized or plasticizable polyvinyl chloride resins) plus mannolactic acid, (4) a 10% solution of a polyamide, 1% Tenite II (cellulose acetate butyrate molding compound), and 5% rosin, and (5) a solution of 5% VMCH and 2% rosin. The average thickness of these coatings is 0.0002 in., about three times that of hot-dip tin coatings.—PDA.

5.3 **Alloy Additions and Efficiency of Hot Galvanizing Baths.** A. Gordet. *Met. et Constr. Mecan.*, 80, 26, Mar.; 35-37, Apr.; 39-41, May; 21-22, July; 17, 19, Aug; 21, Sept.; 41, 43, Oct. (1948).—MA.

5.3 **Hot-Dipped Aluminum Coatings on Steel.** B. P. Finkbone. *Metals Handbook, ASM*, 1948, 704-705.

The production properties, fabrication and possible uses of aluminized steel are described.—MA.

5.3 **Sprayed Metal Coatings.** R. A. Ehrhardt and A. Mendizza. *Metals Handbook, ASM*, 1948, 720-721.

Methods of metal spraying and their use for increasing resistance to corrosion, reclaiming of undersized or worn parts, and hard surfacing are dealt with. 25 references are given.—MA.

5.3 **Metal Spraying.** A. R. Collins. *J. Inst. Automotive Aeronaut. Eng.*, 8, 74-81; discussion 81-82 (1948). *J. Iron Steel Inst. (Abs.)*, 161, 160 (1949).

A comprehensive account is given of the construction of a metal-spraying gun, the preparation of the surface to be sprayed, spraying techniques, the properties of sprayed metal, and some mechanical and maintenance applications.—MA.

5.3 **Metallization.** W. E. Ballard. *J. Oil Col. Chem. Assoc.*, 32, No. 344, 93-4 (1949).

A wide variety of metals can be sprayed from a flame gun. Zinc and aluminum are normally used to give highly protective coatings. Painting is necessary to improve the unattractive appearance of these finishes, which are porous and irregular.—RPI.

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• Non-Metallic Coatings

5.4, 8.8

Chemical Resistant Coating. *Ind. Fin.*, 25, No. 5, 104 (1949) Mar.

The Hanson-Van-Winkle-Munning Co., Matawan, N. J., announces the development of Kote-Rax Grade K, a superior rack-coating designed to insulate and protect plating racks and fixtures in all types of electroplating and anodizing solutions. This formulation has excellent chemical resistance, and is free from any tendency to introduce organic impurities into bright plating solutions. In the application procedure, only two dips are required to obtain a final coating. Kote-Rax, Grade K is 100% solids. This new rack coating belongs to a group of compounds usually called "plastisols."—ALL.

5.4, 3.5, 6.1, 6.2

Developments in High Temperature Ceramics on Metals. R. P. Harner, Ferro-Enamel Corp. *Steel Proc.*, 35, No. 6, 294-295 (1949) June.

Discussion of development of ceramic coating that would protect mild steel and heat resistant alloys against oxidation corrosion and gas corrosion, also coatings that would provide thermal insulation to pipe. Several coatings are mentioned, among them L625/2056 that most nearly met specifications sought. Among metals adaptable for this coating are Ti-namel, Inconel, and stainless steel.—INCO.

5.4, 6.2

Further Steps in Vitreous Enamels for Aluminum. *Ind. Fin.*, 1949, 508, Mar.

Recent American developments in the vitreous anamelling of aluminum are briefly reviewed.—MA.

5.4, 4.2

Climatic Conditions and Paint Behavior. E. Haimann. *Decorator*, 48, No. 562, 71-2 (1949).

The various features of climate affecting the breakdown of paint films are described. Paint behavior in regions with widely varying climates is contrasted.—RPI.

MATERIALS OF CONSTRUCTION

• Non-Ferrous Metals

6.2

Commercial Wrought Aluminum Alloys. J. A. Nock, Jr. *ASM. "Physical Metallurgy of Aluminum Alloys,"* 1946, 167-199.

Deals with alloy classification, heat-treatable and non-heat-treatable wrought alloys, Alclad products, formability, welding and brazing, corrosion resistance, products available, and applications. Numerous illustrations. 18 ref.—BLR.

6.2

Research Toward Development of Non-Corrosive Metals and Magnetic Alloys, and the Production of Magnetic Alloys by Powder Metallurgy. Part II. Bernt Roald, George Condon and Frederick Keihm, Lehigh University, *Eleventh Quarterly Report; U. S. Dept. of the Army, Contract No. W36-039-SC*.

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2033 (1948) Dec. *Prev. Det. Absts.*, 7, 283-2832 (11B) Met. 53 (1949).

This progress report consists of four sections: 1) the corrosion of aluminum alloys in neutral electrolytes in the presence of hydrogen peroxide as accelerator, 2) the corrosion of aluminum alloys under high oxygen pressure, 3) the corrosion mechanism of aluminum coupled with stainless steel, and 4) the mechanism of solution of pure magnesium in dilute acids and its corrosion rate in neutral electrolytes under high oxygen pressure.—PDA.

Properties of Titanium and Titanium Alloys. *Metal Prog.*, 55, No. 3, 345-368 (1949) Mar.

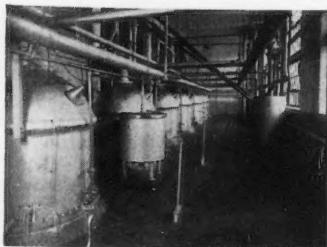
Nine articles concerning properties of titanium, and a bibliography on titanium are included in this series. Considerable progress in alloying is reported in the last five articles of this series; serviceable titanium alloys are in prospect, both for use at normal and at elevated temperatures. The articles included in this series are as follows: composition, structure and properties of iodide titanium; properties of wrought commercially pure titanium prepared by arc melting and casting; fatigue and corrosion of sintered and rolled titanium; engineering properties of sintered and rolled titanium; mechanical properties of wrought titanium alloys made by arc melting or by sintering; properties of binary sintered and rolled titanium alloys; high-temperature properties of titanium alloy castings; constitution of sintered and worked titanium nickel alloys; properties of melted and forged titanium chromium alloys. The bibliography includes gen-

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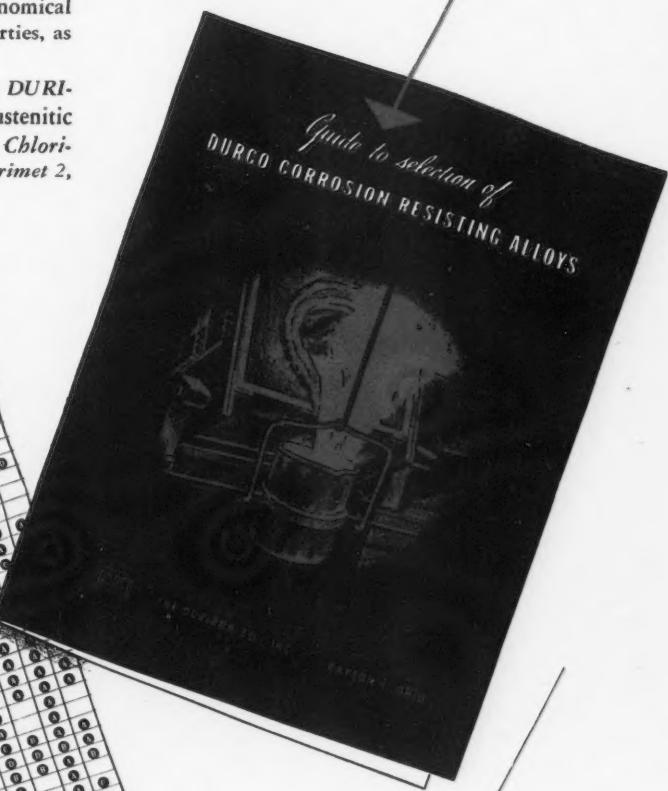
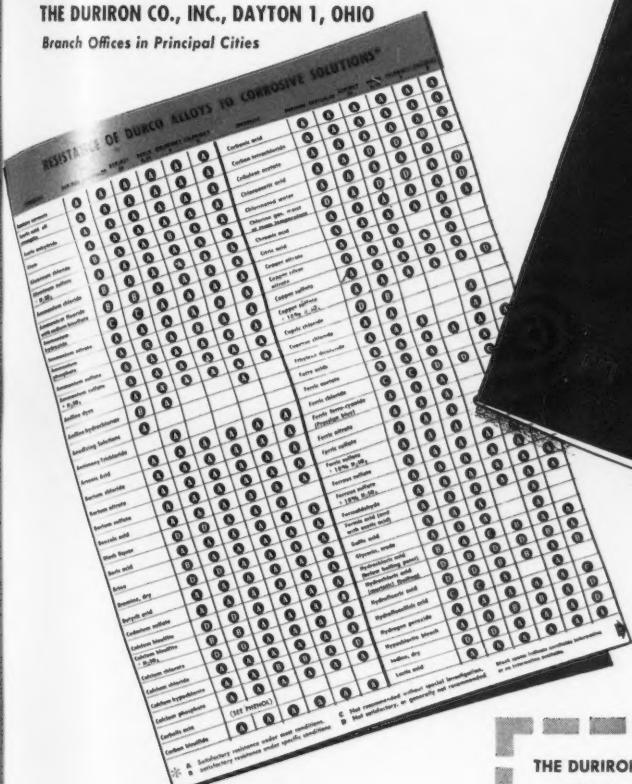
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